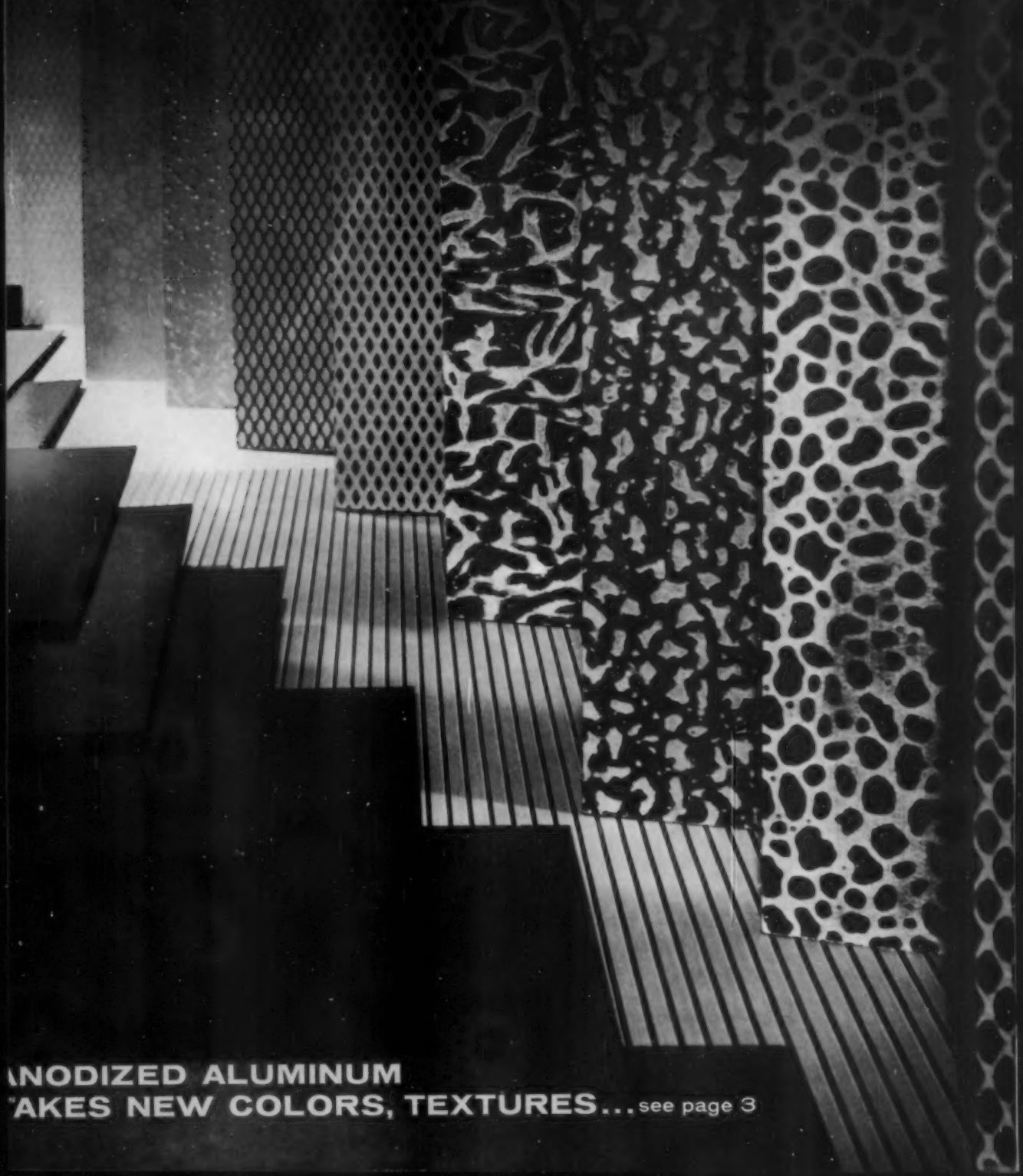
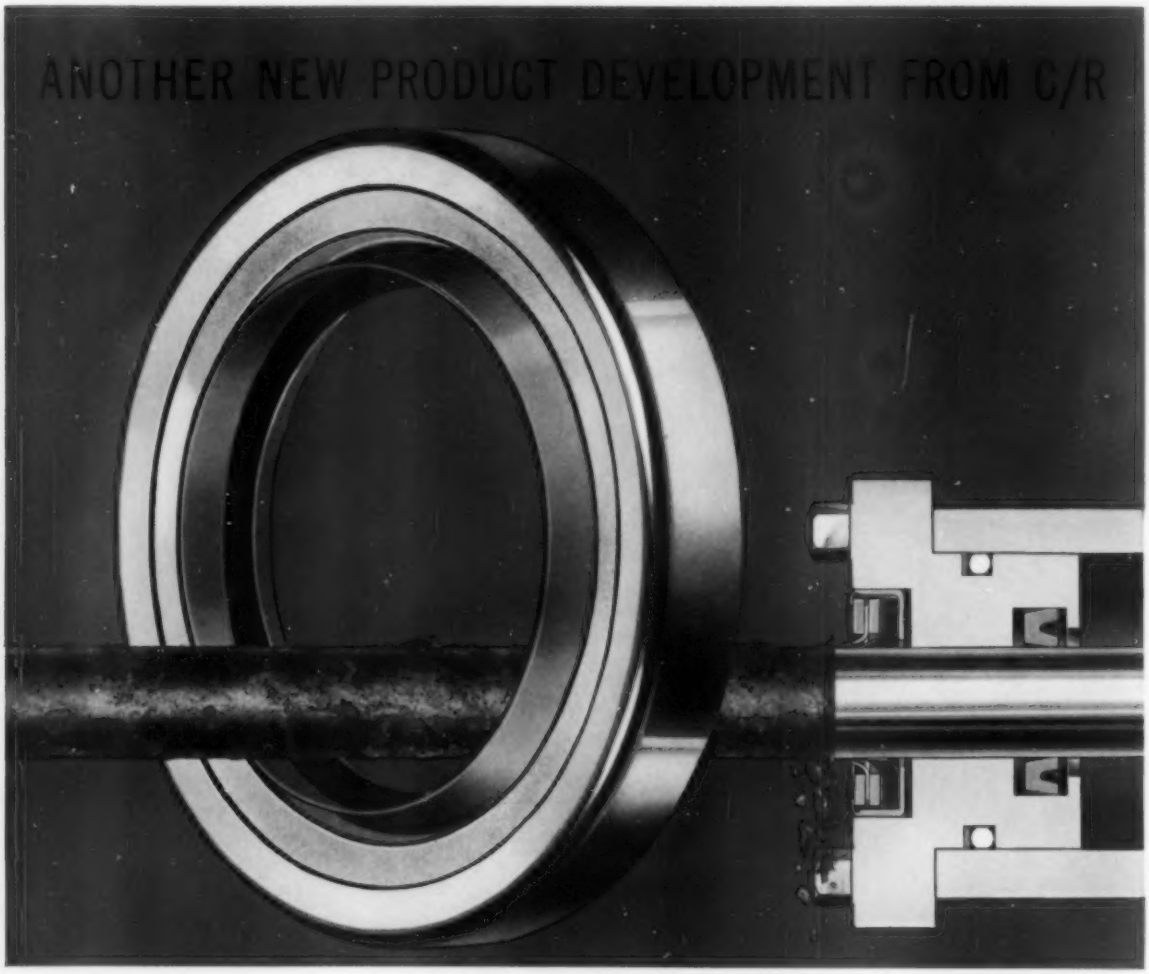
$3 A YEAR

PRODUCT ENGINEERING

cGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MARCH 28, 1960



NODIZED ALUMINUM
AKES NEW COLORS, TEXTURES... see page 3



New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

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C/R

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

March 28, 1960 Vol. 31, No. 13

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(Advertisement)

Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel (active)
Inconel (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

Publication Number	Name
A232 . . .	Corrosion Problems in Nuclear Reactor Power Stations
A59	Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels
A62	A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere
A137 . . .	Corrosion by Some Organic Acids and Related Compounds
A144 . . .	Some Observations of the Potentials of Stainless Steels in Flowing Sea Water

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

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The INTERNATIONAL NICKEL COMPANY, Inc.
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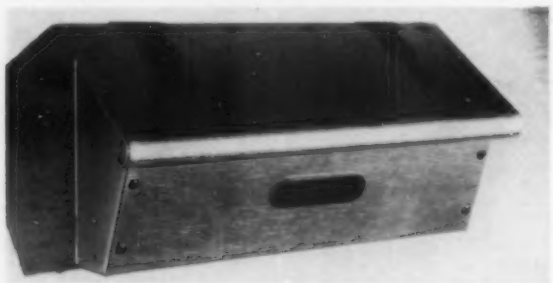
INTERESTING TO NOTE

New Patterns for Aluminum

One hundred years ago, the following note was published in the *Scientific American*. ". . . Aluminum, the metal of which we have heard so much during the past few years, does not appear to be about to realize the brilliant expectations which were formed at the time of its first successful production . . ." How times have changed!

Our cover shows some of the many new aluminum patterns as a result of a new process developed by Kaiser Aluminum Co, Oakland, Calif. Two sheets of dissimilar aluminum alloys are laminated, then embossed in a pattern. When the resulting sheet is anodized, various sunfast colors result. This mailbox (manufactured by the Macklandburg-Duncan Co., Oklahoma City, Okla) exemplifies how these various embossed sheets can be used in designing a product. For further design details on the Kaiser process, see page 89.



Who Says Cars Were Better?

Mention automobile design to any engineer and he'll say, "Give me a chance to design a car and I'll do it better." Our article on page 71, using the automobile as an example, shows how some of the trifles in product design can make a product successful.

Many of them have become the accessories that we take for granted as we spin along in today's cars—going over some of the old car ads, we've discovered enough to discourage yearnings for "the good old days."

In 1910, a New Jersey concern offered a wire-screen "windshield." While the device in no way detracted from the fresh-air feel of open-car driving, it was advertised as allowing a motorist to drive without goggles and "avoid annoyance from insects." Incidentally, before the windshield wiper came into common use, motorists were advised to apply a mixture of kerosene, oil and glycerine on windshields to keep the glass clear of rain, snow or ice.

Traveling any distance 50 years ago was quite an ordeal. A journal of the day advised tourists motoring from Chicago to Denver to make adequate preparation and take the following equipment: "Extra cans of oil, plenty of rope, a block and tackle, a small electric light to help you read the guidebooks at night, a supply of inner tubes, a coil of copper wire that is 'so necessary on every run,' a bottle of kerosene to remove carbon from the cylinders, a varied supply of bolts, a collapsible canvas pail for carrying radiator water if a bracket should break, several sparkplugs, a tool kit, a small soldering iron for leaks in the radiator, a pump or air bottles, and a can of grease."

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A McGRAW-HILL PUBLICATION

March 28, 1960 Vol. 31, No. 13

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N.Y.

PRODUCT ENGINEERING is published weekly — with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, NY. See Index to Advertisers for directions regarding subscription or change in address.
UNITED STATES subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Second-class postage paid at Albany, NY, USA.

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In 1910, thirty-six new motor-car companies were formed in Detroit during the first eight months. And any motorist traveling from New York to Chicago, had to buy license plates in Pennsylvania, Maryland and New Jersey—just to pass through.

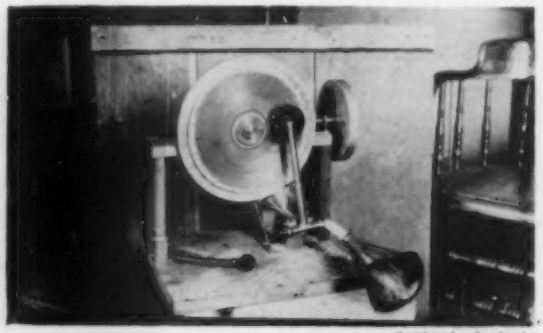
When Edison Out-rang Bell

"Lack of money is almost the only obstacle to achieving imaginative pioneering in basic research . . ." says William Fox, chief engineer, Convair (p 65). But it's not all dollars and cents; an inventor must also be a salesman.

There have been many instances where good inventors were outsold in the market place because they lacked salesmanship: Joseph Henry delayed publication of his paper on electromagnetic induction and lost out to Faraday; John Fitch had a working steamboat 11 years before Fulton, one of the best salesmen-inventors, cruised his Clermont up the Hudson. But perhaps, the least known example is Alexander Graham Bell's development of the phonograph.

After Edison bewildered his Menlo Park staff by playing "Mary Had a Little Lamb" on a tinfoil cylinder, the "wizard" did not make immediate improvements because of an agreement to spend the next five years developing the New York City electric light and power system. This gave Bell opportunity to take the lead in developing a successful recording machine. Together with an associate, Charles S. Tainter, Bell founded the Volta Laboratory Association with the $10,000 Volta prize he had received in Europe for the invention of the telephone. By 1881, the Volta group had improved the Edison tinfoil machine to some extent. Instead of using Edison's stylus-and-diaphragm technique, Bell reproduced sounds with a jet of air under pressure.

Tainter described the recording in his notes on July 7, 1881: "The apparatus being ready, the valve upon the top of the air cylinder was opened slightly until a pressure of about 100 lb was indicated by the gage. The phonograph cylinder was then rotated, and the sounds produced by the escaping air could be heard, and the words understood at a distance of at least eight feet from the phonograph."



Smithsonian Institution

Alexander G. Bell's Graphophone

By 1885, the Volta associates filed a number of applications for patents. They then formed the American Graphophone Co to manufacture and sell their machines. Edison awakened to the fact that he was about to be beaten in the market place. His tremendous competitive spirit kept him working night and day until he succeeded in developing a practical talking machine. As a salesman, Edison convinced his backers and the public that the Edison machine was best because he was the phonograph's inventor.

Curiously, the first mention of the idea of a phonograph was not made by Bell or Edison, but by Cyrano de Bergerac in 1656. In his *Comic History of the States and Empires of the Moon*, he described a moon voyager finding a mechanism in which, ". . . only ears suffice. When a man desires to read . . . he places the needle on the chapter to be heard and there comes, as from the mouth of a man, all those clear and separate sounds which make up the Lunarians' tongue." —Benedict A. Leeburger Jr

COMING NEXT WEEK IN PRODUCT ENGINEERING

. . . 5 Graphical Methods for Designing Four-bar Linkages
This roundup will cover the linkages that can generate an approximately straight-line path.

. . . The Best Way to Mark Your Part
Scribing, stamping, etching are a few of the identification methods discussed.

. . . For Best Results with Printed Wiring
Answers to specific design problems you face when printed-circuit boards are the choice.

. . . 10 Ways to Conceal Fasteners
How to improve appearance of instrument panels by hiding screw heads.

. . . When an Engineering Firm Needs Aid from a Consultant
Exclusive interview with Arthur D Little Inc's outgoing president, Raymond Stevens.

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DEVELOPMENTS TO WATCH...

New plastic on the horizon

Higher burst strength than polyethylene, excellent toughness and impact strength, and outstanding resistance to cold flow, are among the advantages claimed for a new member of the olefin (ethylene-propylene) family of plastics that's now headed for commercial production. Its name: polybutene-1.

In most physical properties, the newcomer is intermediate between standard and linear polyethylene; but it seems to have complete freedom from stress cracking, a problem that has long troubled the older plastics.

Several companies are working with this material. First to reach commercial production in the US will likely be Petro-Tex Chemical Corp, now building a large-scale pilot plant. It promises good-size quantities for engineering evaluation before the end of this year.

Researchers report progress toward ductile ceramics

New reports on ductility of ceramic-type materials—these, to the North Carolina State College Conference on Mechanical Properties of Ceramics—bring increased hope that methods can be developed to achieve a permanent and practical result.

F. G. Satkiewicz of Norton Co told of experiments with magnesium oxide crystals doped with nickel oxide and chromium oxide. These, he said, have much higher yield strength than undoped crystals and still exhibited plastic behavior. Furthermore, "crystals containing an as-yet-unidentified cloudiness were found to be more plastic than ordinarily MgO" and less likely to propagate fractures.

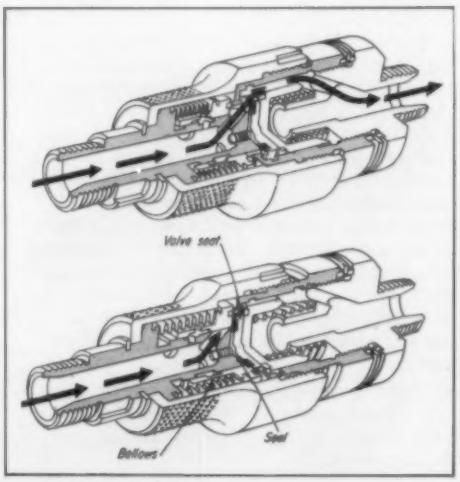
At the same meeting, E. R. Parker of U of California reported that many nonmetallic ionic (ceramic) solids having a cubic structure similar to sodium chloride and cesium chloride, which have previously been shown to possess ductility under certain conditions (*PE*—Sep 21, 59, p 14), "exhibited relatively large amounts of ductility at ambient temperatures when tested in single-crystal form." Under certain conditions, they say, MgO single crystals can be deformed at room temperature with a maximum strain at fracture as high as 20%.

British develop self-sealing, no-spill coupling

A self-sealing coupling that works on vacuum as well as low-pressure hydraulic lines (see diagram) has been developed by the UKAEA and is now going into production at Seton Creaghe Engineering Ltd, Trading Estate, London NW 10, England.

The unit, said to have less than 0.002% volume spillage on disconnection, is to be made in nominal bore sizes of ⅛ to 4 in., for use on lines handling both gases and liquids.

Ability of the valve to operate on vacuum as well as pressure lines stems from its use of a bellows that holds the delivery side tightly closed by pressure against a sealing ring. The bellows, in turn, is held under constant pressure by the liquid in the pipe line, one end being attached inside the pipe so only the end that carries the valve can move.



COUPLING DIAGRAMS show coupling closed and with liquid flowing (top); screw thread is open to stop flow (bottom). Seaton Creaghe will make it in stainless, brass, and aluminum; is also developing a high-pressure model.

(Advertisement)

BOLT LENGTH vs. TORQUE RETENTION

Bolt length and bolt torque are important factors in maintaining flange loads on gasketed joints. New engineering studies show the extent of these effects to be greater than anticipated.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

Although retention of bolt torque on gasketed joints can be a function of several factors, two important ones concern the bolt itself: its length and its initial torque load.

Recent tests were conducted at the Armstrong Research and Development Center to establish (1) the relation of bolt length to torque retention; and (2) how torque retention varies with the amount of initial torque involved.

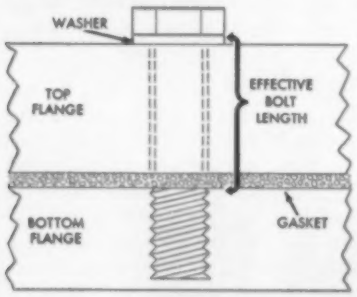


Figure 1. Here bolt length is defined as the distance from the underside of the bolt head to the face of the opposing flange—including compressed gasket thickness and any washer.

In these tests, separate steel flanges were prepared to accommodate three different bolt lengths—½", 1", and 1½". (See Figure 1 for definition of bolt length.) The flanges were gasketed with an Armstrong asbestos material—Accopac AN-890—in ⅛2" gauge. The only variables in these tests were bolt length and initial torque values.

After the bolts were torqued to specific loads at room temperature, the flanges were placed in an oven at 300° F. for a period of 18 hours. While the flanges were still hot, the torque was checked again and the percentage of retained torque was figured. Figure 2 shows the results of these tests.

The chart shows clearly that low initial torque loads lose proportionately more torque than higher loads. At 10 ft-lbs. of initial torque, for example, the average torque loss for the three bolt sizes tested was 37%. But at 25 ft-lbs. of initial torque, the average torque loss was only about 8%.

The tests also indicate that longer bolts retain torque better than short bolts. And the higher the initial torque, the more significant the difference in torque retention between short bolts and long bolts.

These results are, of course, what was anticipated in quality. However, in quantity, the difference in torque retention incurred by varying bolt lengths and initial torques was significantly greater than had been expected.

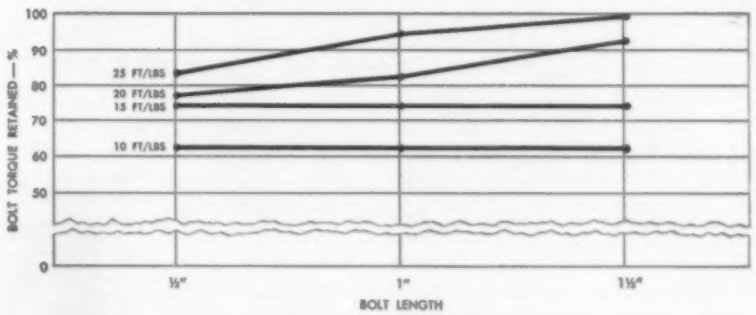


Figure 2. Curves show % of initial torque retained after 18 hours at 300° F. Initial torque is indicated at beginning of each curve. 5/16-24 NF hard steel bolts are used.

In summary, maximum retention of torque is assured primarily by using the longest bolts possible consistent with the design; and by producing maximum elongation in the bolts by torquing them to recommended limits.

The resulting flange loads will usually be well in excess of the seal points of most resilient gaskets.

If you have a specific problem related to torque retention in gasketed joints, we will be glad to make suggestions. Just write to us, giving details of your application. Also, if you'd like a copy of our Gasket Design Manual, write Armstrong Cork Company, Industrial Division, 7103 Irvin St., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

1860–1960 Beginning our second century of progress

Mesa transistors will be cheapest, engineers predict

In the field of low-power (to 100 milliwatts) transistors, cost analysis indicates the mesa-type, diffused-base silicon transistor will have a substantial cost edge over germanium junction and mesa transistors, says A. J. Anderson of Western Electric.

This assumes volume production and "sufficient development effort and time to solve outstanding problems"—about 4 to 6 years. At that point, though, he believes the silicon type will cost at least a third less to produce than any of the others. For one thing, he says, "silicon seems to be substantially more tractable in diffusion behavior," and formation of junctions should be easier; while the cost of slicing, cleaning, and etching the wafers to the mesa shape is roughly the same.

In diodes, the germanium-point contact type now has the cost advantage; but Anderson postulates a diffused-silicon "austerity" diode, "with moderate characteristics, by diffused-junction standards, but still quite good by point-contact standards" could be made at about half the cost of the germanium type. This would be an encapsulated unit that "would offer considerable cost advantages."

One indication that others share Anderson's faith in silicon—and in the mesa transistor in particular—is the number of companies now preparing to make them and developing improved types. Among the newest is one just announced by National Semiconductor. It's rectangular in shape (for lower current densities and therefore lower junction temperatures); yet is able to provide output capacitances on the order of 4 micromicrofarads. It will operate at temperatures to 400F; and, says National semiconductor, leakage currents will be held to 1 to 5 millimicroamps.

Self-detecting adhesives come to market

Fluorescent adhesives are being marketed by Armour Alliance Industries, Alliance, O. Primary aim: To show up (under black light) leaks and smudges that may interfere with smooth, stain-free finishing of wood products. The idea could have other applications, though. Armour says the dye does not interfere with adhesive properties, is harmless, and invisible to the naked eye. It doesn't increase the price, either, says Armour. Its Timbond resin adhesives will all contain the dye from now on.

Airflow switch designed for safety control

For automatic control of electrical equipment requiring forced-draft circulation and cooling (aircooled motors and transformers, electronic equipment, heating and drying units), Londex, Ltd, London S E 20, has a new switch that acts much like a paddlewheel. It can be used, the company says, on any application where the airflow is 275 cu ft/min or more.

AIR VANE is key operating unit in new British safety switch.

The switch consists of a vane or flag with a counterbalance, attached to a stainless steel shaft (see illustration). The vane is positioned so that it is tilted by the pressure of the air, thus operating an electrical switch mounted on its shaft. The switch can be arranged to either make or break an external circuit when the airflow is interrupted.

Several models have been designed. The basic unit has a 3½-in.-square vane and employs a mercury switch (1 amp, 250 v, ac); but for applications where the unit is subject to vibration, a snap-action switch (2 amp, 440 v) can be substituted; and relays can also be included in the casing. There is also a flameproof model, in which the shaft is coupled magnetically to the switching mechanism so there is no need for an opening in the casing to permit entry of the shaft. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Is there confusion in shear strength?

Shear-strength tests need more study and a lot more standardization, says Durez Plastics. It's not that tests are lacking; but that so many variants are used.

For instance, many companies, in developing data on shear strength of plastics, base their tests on Method 1041, of Military Standard LP406. But this test, itself, has several variations, and each user adds modifications of his own.

The LP406 test may be made either on a bar or cylindrical rod, and may either be "single shear" or "double shear." Results are not directly comparable.

As Durez points out, the problem of noncomparable tests is especially acute when shear strength is involved, because "shear strength is a strange property that doesn't seem to correlate with anything else."

Light and current soften semiconductors

Mechanical properties of semiconductors can be altered by both light and electricity, G. C. Kuczynski of Notre Dame told the North Carolina State College Conference on Engineering Ceramics.

Light wavelengths between 2 and 4 microns decrease the surface hardness of germanium and silicon—both n-types and p-types—by as much as 60%; and, when germanium is made the anode in an electrolytic solution, its surface hardness may decrease as much as 30%. Similar, but less pronounced effects have been observed in other intermetallic compounds.

Significance of the finding may be threefold: It may help to explain aberrations in semiconductor behavior; to develop semiconductors with special characteristics; and to open a new way to increase the ductility of ceramic-type materials (see p 6).

First radioisotope out to pasture?

Have man-made radioactive materials replaced naturally occurring radium, the first and best-known radiation source? US production of the natural isotope was terminated in 1955. But imports have continued at a steady rate.

Demand for certain items for which radium or its derivatives (eg, radon) are still the preferred materials will probably maintain imports at the current level. But, over the long range, says the Bureau of Mines, the variety of man-made isotopes and their potentially lower cost should enable them to take a commanding position.

Most new radiation products (lamps, signaling devices, energy-conversion units, and batteries) will probably be designed for man-made isotopes.

briefs . . .

A liquid control "rod" is planned as an added safety feature for the big Yankee Atomic Electric plant, now being built at Rowe, Mass.

The idea is a simple one. The element boron has the ability to absorb large quantities of neutrons, the atomic particles that initiate energy-producing nuclear chain reactions, thus stopping the reaction.

Normally, the boron is incorporated in steel rods that are lowered into the reactor as needed. The Yankee plant will have rods of this type. But, as an extra precaution, plans are being made to feed boron—in the well-known forms of boric acid—into the coolant water in case a runaway reaction occurs.

Platinum-clad stainless, made by a new process, paves the way for a new line of laboratory ware that's relatively low in cost, says Fisher Scientific Co, Pittsburgh 19. The cladding is a platinum-rhodium sheet 0.002 in. thick; the base, 0.033 in. stainless. The combination is claimed to be four times as strong as solid platinum ware, stands temperatures at least to 1000 F, and has excellent chemical resistance. It's pilfer-resistant, too. Fisher points out: it's almost impossible to remove the platinum. First products to be introduced are 40cc crucibles ($48) and 100cc evaporation dishes ($64.80). —ARG

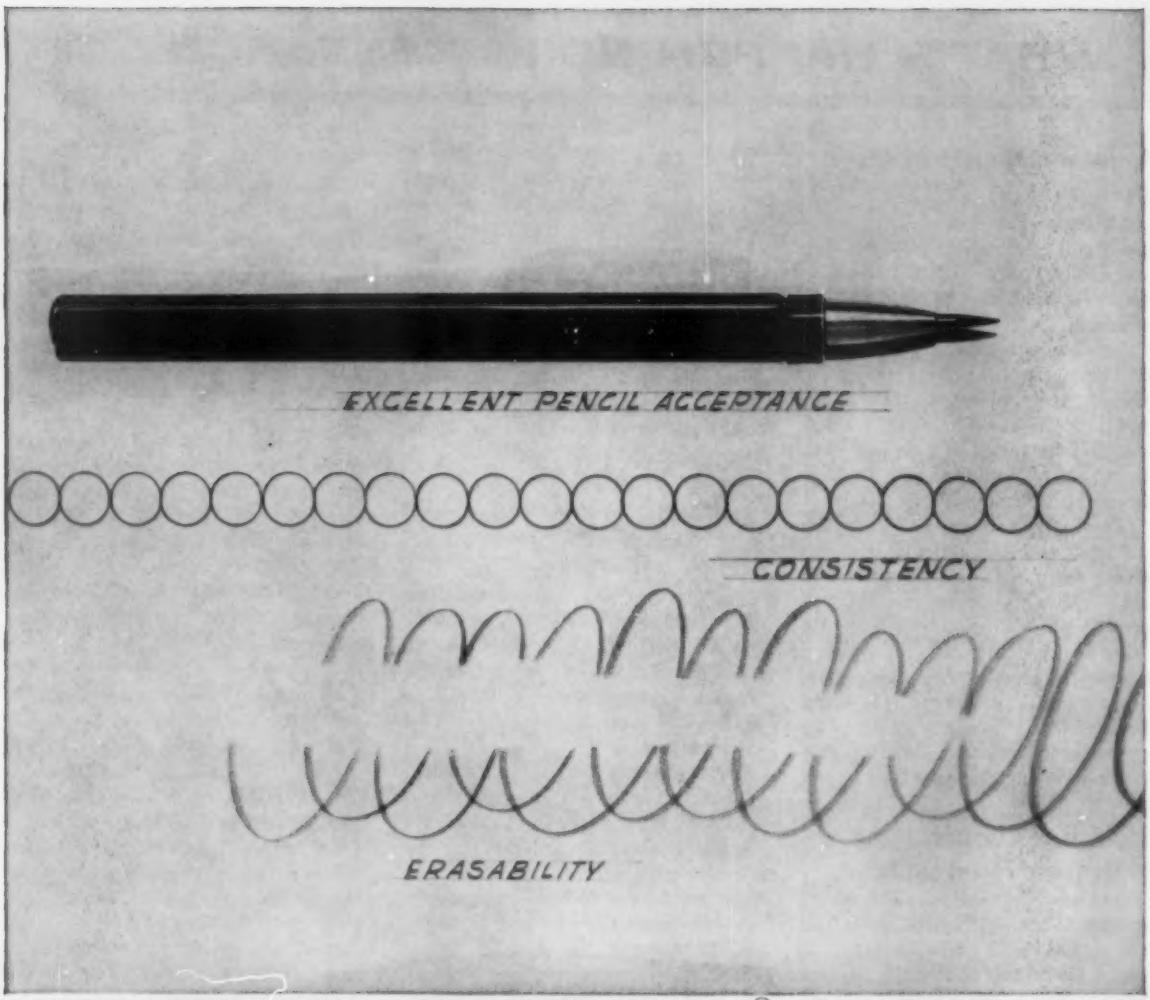
Concentricity a la Chart

A machine that maintains concentricity to within 0.000,005 in. is now being built in England by Optical Measuring Tool Ltd for laboratory use. It has a measuring range of ⅛ to 6 in. on ID, ⅛ to 6 in. on OD; has magnifications of 1000 and 5000 times.

A spindle, carrying a spring-loaded stylus to contact the test piece, rotates (at 1 rpm) in an air bearing. As it moves, the stylus generates a signal that is amplified and fed to a chart recorder on which radial motion of 0.05 in. represents 0.000,01 in. at 5000 magnification.

Newall Group Sales, Ltd, Old Fletton, Peterborough, England is marketing it. Price (US equivalent) is about $4700.

ROUNDNESS-MEASURING MACHINE, developed in England, may be mounted on its own stand, as shown, or assembled to a toolmaker's microscope. Recording unit (right) includes air filter, pressure regulators, gages.



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BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

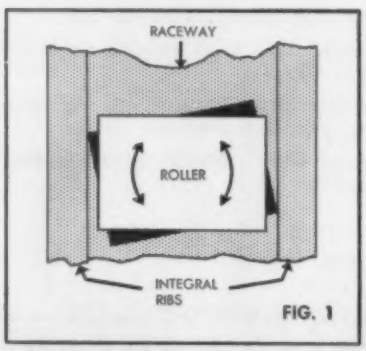
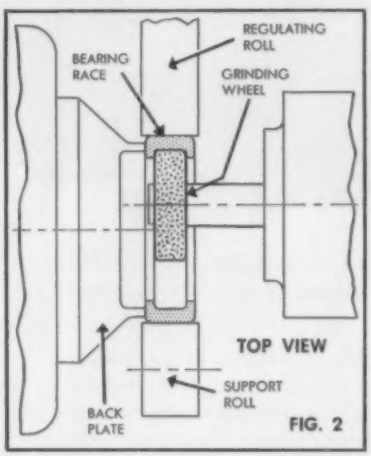
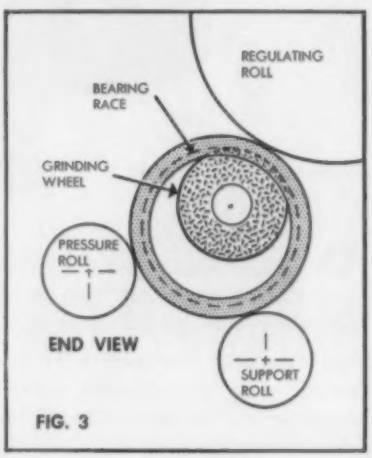


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

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FROM WASHINGTON . . .

Basic research patents to get congressional airing

An important bill aimed at blocking patent rights on research paid for by the government has emerged from a month-long study by the Senate Patents Subcommittee. It would give the National Science Foundation a strong voice in saying whether a company may be given patent rights growing out of such research.

In simple terms, this is what the bill does: if Defense or any other government agency wants to give a company patent rights on a contract that is primarily for basic research, it must submit the contract to NSF and the Justice Dept for review. These agencies could then express a formal opinion. The burden of justifying the awarding of patent rights then falls on the agency letting the contract.

Subcommittee chairman Joseph C. O'Mahoney (D-Wyo) scored the NSF for "surprising indifference" to the kind of patent clauses used in its own and other agencies' research contracts. Basic research in the US is being hampered by allowing a company to restrict the free flow of information and patent rights developed through taxpayer-financed research, he says. Industry will argue, however, that taking away patent possibilities cuts its research incentive. Since the government supports more basic research than private industry, this has a damping effect on the whole US research posture. Industry will undoubtedly oppose the bill as more red tape in the letting of contracts.

Sen O'Mahoney hopes to hold hearings this session, but no action is likely before next year.

AF stretches out expensive projects with additional step

An additional contracting step has been injected in Air Force weapon-system development projects. The effect will be to stretch out the hardware fabrication schedules, and the award of major subcontracts.

Called "Phase Alpha," the Air Force regulation requires prime contractors to "further refine" study proposals during source selection competition before a "Phase One" development contract is awarded.

First project to be affected by the new procedure is the Dyna-soar manned boost-glide vehicle. Indications are the major subcontracts will not be awarded until Phase Alpha is completed later this spring.

The new procedure reflects the Air Force's increased caution on costly new projects in the face of rising costs, stringent budget restrictions, and the technological unknowns of manned space flight.

NBS breaks one division to form two new ones

New atomic physics scientific division has been established by the National Bureau of Standards with Dr Lewis M. Branscomb in charge.

The Atomic Physics Division was created by partitioning the Atomic and Radiation Physics Division. The other half of the old division has been renamed the Radiation Physics Division, with L. S. Taylor as its chief.

Areas of research in the new division include: precise determination of atomic constants; quantitative studies of the microscopic, mutual interactions of ions, atoms, molecules, and their constituent particles; and studies of the solid state, particularly of semiconductors.

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THE ENGINEERING WEEK

Detroit Readies 'Small' Compact to Meet Foreign Competition

DETROIT—The impact of the "compact" on the US car industry has been considerable (Chrysler Corp's Dodge Dart is outselling the standard Dodge by 4-1). And, as a result, signposts along Detroit's new road to design are just beginning to appear. Though still unofficial, this much is apparent:

1. There'll be no basic change in the prestige cars, big (Cadillac) or small (Thunderbird).

2. Also, no basic change in the compact versions of the low-price cars is planned, except perhaps for a readjustment in production schedules in favor of compacts by most companies.

3. But look for extension of the compact concept throughout the medium-price range—the introduction of Ford's Comet, for example.

4. There'll be more design for both cost reduction and flexibility.

5. Look for introduction of new models, smaller than the compacts (less than 100-in. wheelbase), to compete with still-flourishing foreign cars.

Introduction of entirely new models presents Detroit engineers with a unique opportunity to bring out features already tested and put on the shelf against just such a day. Detroit, of course, is traditionally manacled to mythical release dates and any prior mention of planned innovations is officially denied. Yet there are enough indications to sketch at least the rough outline of things to come:

- Unitized construction will probably win, hands down. This has been the trend in all successful new Detroit designs in recent years.
- Where possible, engines will be made of aluminum, will be watercooled and located up front.
- Compression ratios will be low in order to continue use of less expensive "regular" fuels.
- Emphasis will be more on essentials like headroom, footroom, ease of getting in and out; less on frills.

For years, Detroit's problem has been the overloaded front end. It was especially acute in the days of the hp race and it helped to bring about the high-compression engine, which permitted higher power output without added weight.

But recent developments in auto construction have considerably reduced total car weight and power requirements. Additional weight-saving made possible by aluminum engines have changed the picture completely, giving the engineer a freedom of design he didn't know before.

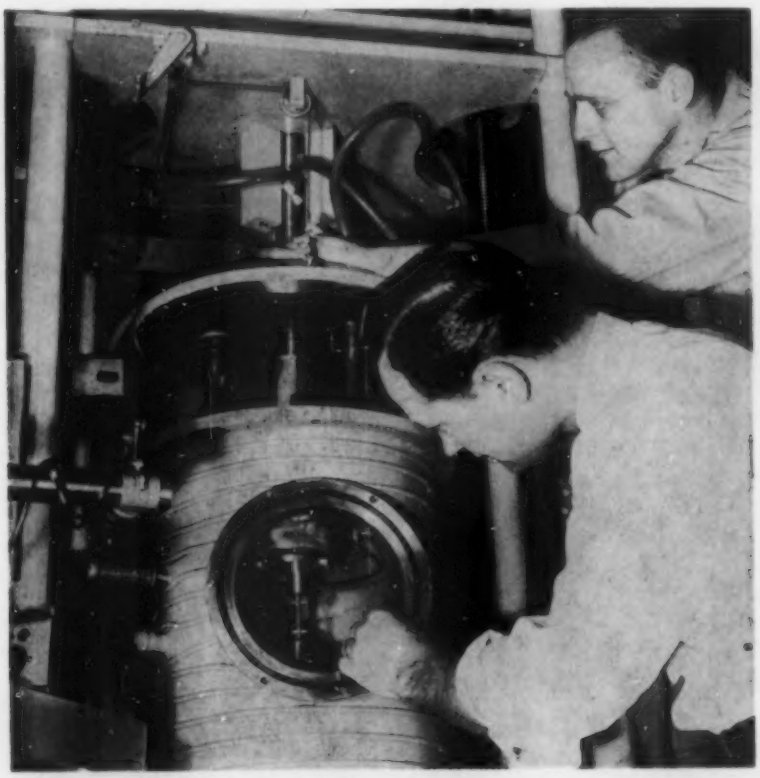
Although aluminum costs more than cast iron, its total savings in machining and in design are winning the day for the light metal.

REAR VS FRONT ENGINE

There is, of course, no sound engineering reason why the engine must be in front—or in back; but rear-engine construction reduces freedom in body styles. For instance, while the Valiant already has a station wagon on the market, and the Falcon is soon to offer one, Corvair will not have one, according to best Detroit rumors. Reason: the engine would not be accessible if the station wagon were loaded.

Noise level of aircooled engines is higher than that of watercooled ones. While this is not objectionable when the engine is mounted in the rear, in a front mounting the noise level would

Material Properties Studied at 4000 F



This apparatus, designed and built at Battelle Memorial Institute, studies properties of refractory metals, graphites, and ceramics at temperatures of 2000 to 4000 F. It gives such information as tensile strength, and compressive stress-strain curves, as well as shear and bearing strength of specimens subjected to high temperatures. The apparatus, as yet unnamed, consists of a loading device, high-temperature vacuum furnace, temperature and strain measurement devices and a power source.

definitely be too high. And water-cooling eliminates the need for a separately fueled car heater.

These restrictions on the design and placement of the engine apply only where car size and customer demand make the availability of a station wagon desirable, exactly the case of cars that would be classed in the medium-price range.

Elimination of the overload problem in the front end now permits a design that has long been absent from the US automotive scene: the front-wheel drive. At least one of the big auto companies is interested in bringing out such a design, but it may not be introduced this year.

POSSIBILITIES OF ENGINE DESIGN

Most small foreign cars have engines with four cylinders or less (some Fiats have two, the Saab has three), so it seems reasonable to expect that an American entry in this field would also be powered by a 4-cylinder engine. It would be extremely desirable to be able to machine such an engine on the same production lines now used for bigger engines. Such a possibility might be afforded by designing the engine as half of a V-8. Chrysler has already introduced the inclined engine, which has met with no user objections, so none is expected for what might be called the angle-4 design. Such a design would also leave plenty of space for mounting the engine accessories, making for easily accessible servicing, a distinct improvement over some crowded designs of the last few years.

This design-by-division might be balanced by its very opposite, by what might be called design-by-multiplication. In this connection it should be recalled that the development work on an engine to be built by assembling modular 2-cylinder units was completed some years ago. In the last few years Detroit has embraced the concept of standardized modular design, at least in the machine-tool field. So why not in engine design? the industry is asking. It could be an ideal way of producing a 4-, a 6-, and an 8-cylinder engine from different numbers of the same components. Under the spur of increased competition and the need to meet European prices, this design might provide both high production rates and flexibility through assembly. —Felix Giordano

India Bids for Engineering Market in US

NEW YORK—The Indian government was fiercely determined to build engineering industries when its nation gained independence in 1947. The effort has been successful enough to make India start looking for export customers in the industrialized West.

Early this month, a six-man delegation from India's Engineering Export Promotion Council of Calcutta began a round of talks here with government officials and businessmen in major US cities that also include Washington, San Francisco and Los Angeles. The delegation has a threefold mission: to find customers for its engineered products; to set up cooperative arrangements whereby Indian firms will become "feeders" to US firms, supplying them with parts and components; and to urge US firms to locate industrial plants in India.

The touring engineers are offering a wide range of engineering products for sale in the US. Heavy industrial items include machine tools; centrifugal pumps, turbine pumps, diesel engines, agricultural equipment, textile machinery and electrical transformers, motors and switchgear. For consumers they are offering sewing machines, electric fans, radios and automobiles.

"So far, we have mostly sold ideas," B. S. Agarwal, leader of the delegation and general manager of Jay Engineering Works, Calcutta, said here. "Few people in the US realize that India can manufacture locomotives, electrical equipment and other heavy items. But the people we have talked with show great interest in what we can offer. We expect orders to follow."

Since independence, India has set production and export targets under two 5-year plans. The first ran from 1951-52 to 1955-56; the second began in 1956-57 and will end in 1960-61. Under the present plan, India hopes to push exports of engineered goods to $100 million, with at least $20 million going to the US. The country now is shipping 112 engineered commodities to 72 countries. Largest volume goes to Far East and Africa.

Particular emphasis is placed on the

Televising Combat Situation

US Marines on maneuvers demonstrate new tactical communications system, which shows rear-echelon command post the combat area on TV screen. Developed for the Marine Corps by Stromberg-Carlson, the system is called Battle Area Surveillance and Integrated Communications (BASIC). Forward observers holding small BASIC message generator, above, set up report on enemy tank movement and check accuracy of message through windows on face of the box. By pressing transmission button, entire message is sent in short burst over standard field-communications equipment. Information is displayed within 3 sec on a tactical map at command post and simultaneously transcribed onto typewritten cards showing target identity, location, numbers and other information. Data can be fed directly to tactical computers for artillery fire control.

"feeder" concept: Indian firms will sign contracts with US firms to supply them with various components for larger assemblies; the Indian firms will get designs and product specifications from the US. The delegates are convinced that Indian industry can comply with most specifications. They point out, for example, that their well-equipped, modern foundries can pour castings ranging from ¼ oz to 6 tons.

INDIA HAS CAPABILITY

The delegates are likewise convinced that India can compete with the rest of the world on price and quality. Agarwal declared that India can produce steel—a basic engineering material—cheaper than any other country in the world, outside of Australia. He attributes low production costs to plentiful local supply of natural resources and very modern equipment in the steel mills. Mill managers have also helped reduce costs by cutting waste with such modern techniques as statistical quality control.

Products from US companies can be made to ASTM standards, Agarwal added. Indian firms also abide by standards of the International Standards Association and have set up their own Indian Standards Association.

Believing that his country can find a place in the industrial world despite well-established competitors, Agarwal claims "If we can just break into the US markets in a small way, people will recognize that our products are good and will reorder. My company manufactures sewing machines. A few years ago, we got an order for 100 machines from the US. Now we are selling 1000 machines a month, and expect to sell up to 5000 shortly."

SEEK HOME-GROWN DESIGN

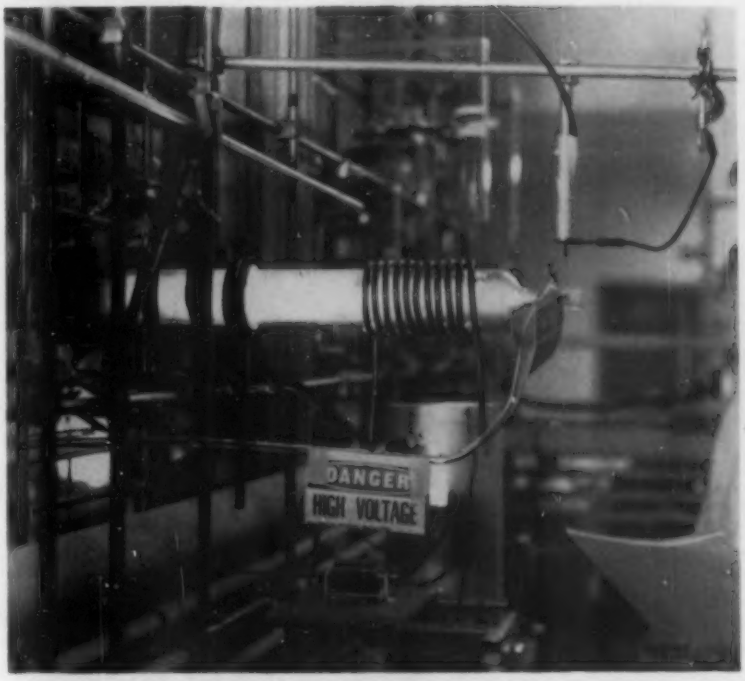
Heretofore, the delegates agreed, India had developed no unique engineering designs nor had she made significant scientific contributions. But delegates also believe that the Indian people have brains and energy, and that technical creation will follow. The government is concentrating increasing effort on scientific and engineering innovation guided by the Council of Scientific and Industrial Research. The council is placing particular emphasis on basic sciences. It is also building nuclear reactors for research on electrical generation. One allied agency, the National Electrochemical Institute, is sponsoring original research on smelting of low-grade manganese. India has plentiful reserves of manganese, but needs economic methods for extracting it.

The industrial aspirations of India's leaders run the gamut of engineering industries. This broad assault is perhaps in part a bolster to national pride. The government is also convinced that India must have industry to support her peoples but, having lean foreign currency reserves, the country cannot purchase all of its industrial equipment abroad. Hence, her leaders believe, the country must build her own capital-equipment industry.

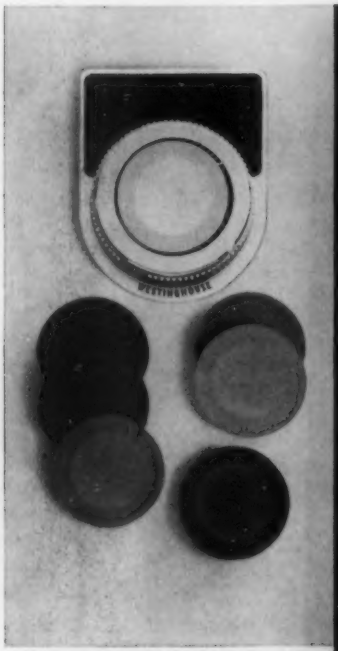
The current campaign to find markets in the US and other industrialized countries is seen as a way to build currency reserves for equipment that must be purchased overseas. The delegation considers the US as one of the most attractive general markets in the world.

The delegation is arguing forcefully for US firms to build plants and equipment in India. New and potentially profitable markets will open in Asia and Africa, they predict, and companies that settle in that area early will be in the position to take advantage of these emerging opportunities. The delegates also feel that the world is coalescing into a few large trade areas—the European Common Market, the Outer Seven Common Market and the Latin American Common Market, for example. Eventually, the delegates believe, the East will form its common market area. And this market will probably be more profitable for engineering industries than the European markets, which are already highly developed. ■

Hydrogen Embrittlement is Probed



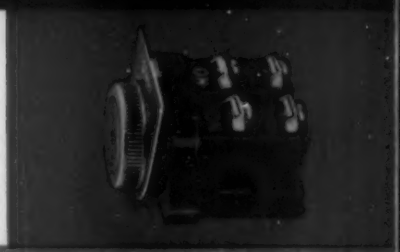
Seeking to pinpoint the cause of hydrogen embrittlement, Stanford Research Institute is checking the reaction of hydrogen atoms with graphite. A radio frequency discharge produces atoms from H_2 molecules in a glass tube several inches in dia and several feet long. At pressures of about 20 microns, the hydrogen atoms travel down tube and impinge on a graphite disk at room temperature. Reaction products are such hydrocarbons as methane, acetylene and higher paraffins. Having made hydrogen atoms react with carbon at room temperature, SRI is convinced such reaction takes place in steel. Result: methane and other hydrocarbon molecules formed in steel's interstitial spaces are too big to diffuse, remain in place and create tremendous pressures. These pressures, coupled with removal of carbon atoms from the lattice position, cause hydrogen embrittlement, SRI believes.



Easily snapped-on plastic caps come in seven colors—red, green, blue, yellow, gray, tan and black—for quick color coding of a pushbutton bank.

Assembled units (right) permit multiple contactors in limited space. As many as six contact blocks can be coupled to a single pushbutton.

Westinghouse Flush Pushbutton (below) with contact blocks. Notice how one fits directly behind the other. Stacking permits controlling many circuits with one button.



YOU GET... TOTAL DESIGN FLEXIBILITY IN THE WESTINGHOUSE FLUSH PUSHBUTTON

circuit flexibility—unique spacesaving design permits as many as six contact blocks to be stacked one behind the other. You operate all circuits with one push of a button . . . a big help when multiple operations are necessary.

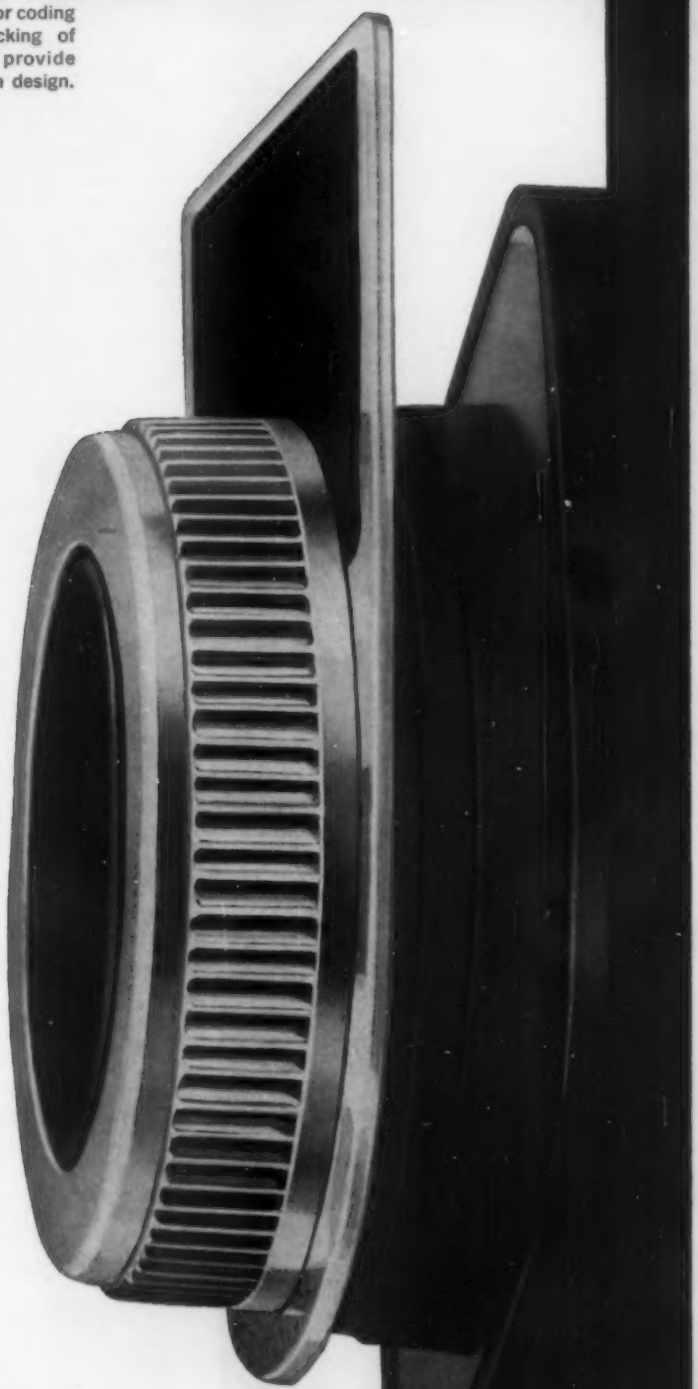
color flexibility—interchangeable chemical-resistant plastic caps come in seven colors: red, green, blue, yellow, tan, gray and black. Choose the best pushbutton for your design and color code it. Permits programming of manual operation using only one model.

function flexibility—choose from a wide range of operators to suit any use. Standard units available include flush head, mushroom head, extended head, selector switches, push-to-test indicating lights and a host of others.

When your design calls for pushbuttons, you'll find what you need in Westinghouse stock. Call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, Standard Controls Div., Beaver, Pennsylvania. J-30313

YOU CAN BE SURE...IF IT'S Westinghouse

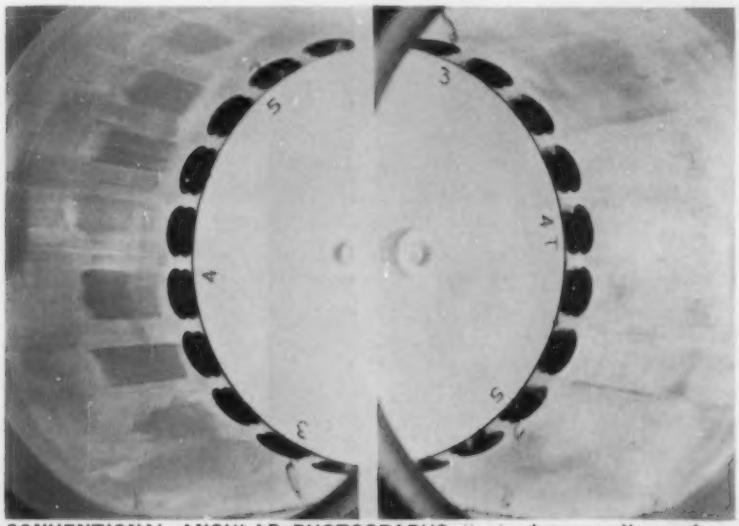
The Westinghouse Flush Pushbutton . . . color coding and multiple stacking of contact blocks provide greater flexibility in design.



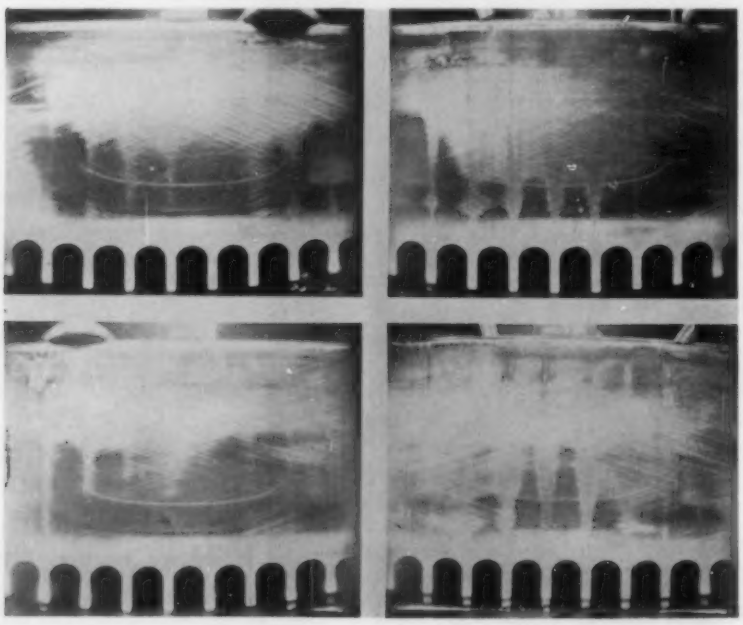
Pinhole-type Camera Cuts Cost, Takes Distortion-free Pictures

DETROIT—Photographs of cylinder walls and port openings, taken of engines undergoing development tests, give a quick check of new designs and material modifications. A major problem, however, is distortion; pictures obtained represent little more than a photographic record of the test.

Detroit Diesel, after years of using standard photographic methods—conventional angular photos, reflected pictures from a conical mirror, positive paper inserted into a liner—now uses a unique "liner camera" that is based on the principle of the pinhole camera. Simple to operate, the liner camera gives distortion-free pictures of a cylinder in its true condition and takes the picture in less time and at less cost than required by former photographic methods used.



CONVENTIONAL ANGULAR PHOTOGRAPHS (top), show receding and unrevealing perspective. Liner is usually split at completion of test to make true evaluation of port areas and cylinder walls. Liner camera pictures (bottom) clearly show port areas and cylinder walls.



HOW IT WORKS

Conventional angular photographs of the port area, taken from above the cylinder liner, are normally inadequate and inaccurate, because of receding and unrevealing perspective. Pictures of the port area reflected from a conical mirror resting on top of the piston are most difficult to interpret because of distortion. The most widely used method, positive paper mounted strips inserted into the liner and held in place against the liner wall by an inflated balloon, is time consuming. It requires stripping the engine to the bare block, and does not always show true port condition.

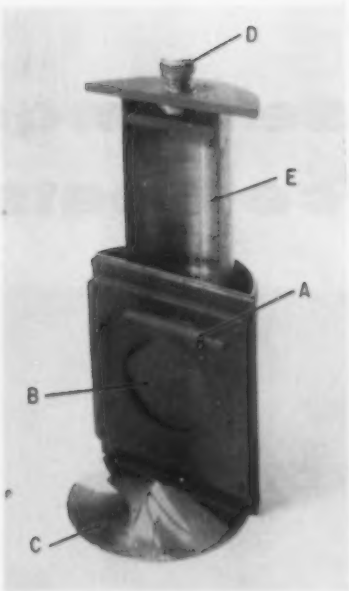
With the liner camera, air-inlet-port deposits and cylinder-wall conditions are photographed at any time during the test period by removing the cylinder head and inserting the camera into the liner bore on top of the piston when the ports are fully exposed. Two pictures are taken inside each liner, one of the blower side and another of the opposite side. Each picture covers slightly over 180° of the liner; when spliced together, they show the condition of the entire liner area.

After the camera is inserted, a bulb shutter is opened. A No. 5 flash bulb is then fired above the liner and its duration of about 1/50 sec controls the exposure time. Shutter is closed, camera removed, film changed, and the camera is ready for the next exposure.

PROBLEMS OF DESIGN

First problem was to construct a film plane free from distortion. Pinhole principle allows universal focus—that is, the focal length can vary without causing an out-of-focus condition. Hence, once the focal plane is set, it is only necessary to hold the ratio of the film plane to the subject plane constant through the pinhole of the camera.

Pinhole diameter was another problem. Too large a pinhole causes a fuzzy or blurred image; too small a diameter increases exposure time and decreases angle of coverage. Equally important: the pinhole must be perfectly round and have clean edges. Thickness of the material in which the pinhole is made, and the diameter



LINER CAMERA developed at Detroit Diesel is composed of: (A) shutter-operating piston; (B) shutter; (C) cone reflector; (D) spring-loaded light-tight lock; and (E) film holder.

of the hole, control the maximum area of coverage.

Detroit Diesel tested various diameter pinholes, from 0.030 to 0.009 in., with optimum results being a 0.012-in. hole in a 0.0015-in. sheet. This gives an angle of coverage of 165° and covers 192° of the cylinder wall. Lighting of the port and liner-wall was solved by placing a cone reflector at the base of the camera.

WHY A PINHOLE

A pinhole is used instead of a lens, because restrictions inside a cylinder liner are such that no lens could be designed to meet the necessary specifications. For example, with a focal length of 2.125 in. (liner-bore dia is 4.25 in.), the *f* stop would be 1000. This requires a diaphragm diameter of 0.002,125 in. For a coverage of 165°, the thickness of the diaphragm could be only 0.000,14 in. Other combinations present equally impossible sizes.

In addition to giving a distortion-free picture, the liner camera, Detroit Diesel reports, is economical. Pictures are taken in less time than by other methods, and processing time is reduced, because negatives are spliced directly, and no retouching or copy negatives are required. ■

Specialists Advise R & D Managers on Creativity

CHICAGO—"An R & D man is not supposed to think on the job—he is supposed to work." This attitude increasingly dominates industrial research labs, according to Prof Morris Stein, a Univ of Chicago psychologist. He was serving on a panel for the university's Eighth Annual Management Conference here.

"Often a firm hires a good creative thinker in the research department and trains him in such a way that he loses his creativity and becomes an organization man," Stein said. "Industry must develop two ladders to success: administrative and creative. If there is only the administrative ladder, creativity will be stifled within the company, and good R & D men will leave for better opportunities."

According to Stein, different creative men require widely varying environments. One man may do his best work in a clean, noiseless room; another in a busy, noisy room: "In the creative stage, all you can do is expose the R & D man to stimulating ideas and leave him alone. The R & D man must have an opportunity to get ideas, and his environment must stimulate thought."

The panel, which also included Thomas Whisler, Univ of Chicago industrial relations professor, and Jules Porsche, Armour & Co central research department manager, agreed that business is committed to the idea that "specialization pays dividends." R & D organizations, they find, are separated from other departments in most companies, and there is no evidence to indicate whether such separation is right or wrong.

According to Porsche, rewards for the creative man take many forms and come from both inside and outside the company. Porsche named money, prestige, accomplishment, working conditions, lab equipment, intellectual atmosphere and friendliness among coworkers as rewards provided by the company.

Important benefits associated with the company, but not provided directly, include good living conditions, good schools for children, good transportation and friendly neighbors. "Although these factors are not provided by the company itself," said Porsche, "the company's location forces the man to live in a certain environment. Dissatisfaction with his environment could prompt an R & D man to leave the company.

"A creative person who is dissatisfied with his job will tend to channel his creative drive outside the company, into hobbies such as painting, music, sculpture, etc.," continued Porsche. "On the other hand, a person content with his job will spend more time thinking about it than he will about outside things. A creative person will find an outlet even if the company does not provide it."

According to the panel, there are two things management can do to forestall personnel problems: Hire only R & D men whose values agree with the company's; and provide a training-apprenticeship program to help new men—especially new graduates—adjust to R & D.

"It generally takes three to four years for recent graduates to adjust to the industrial atmosphere and produce significant ideas," Stein added. "A training program that aids this adjustment provides great benefits."—Bruce Cross, Midwest News Bureau

Outer Seven Acts to Heal Trade Split

VIENNA—Ministers of the 7-nation European Free Trade Association (the Outer Seven) have met here and reaffirmed their desire to prevent a trade split in Europe. Led by Britain and Sweden, the association will start cutting tariffs among members this year with an initial 20% slash due July 1—and has offered to extend this cut to the European Common Market group and to other countries, including the US, on a reciprocal basis.

A firm proposal for such reciprocal agreements will be put on the table by EFTA at a 20-nation powwow in Paris, scheduled for March 29. Even if the proposal is accepted by the European Common Market, however, it will only mean a temporary breathing spell, allowing time for concluding longer term arrangements. There's presently a wide gulf between attitude of EFTA countries—anxious, above all, to conclude an European trading pact—and the Common Market Group, eager to get ahead with its own integration program. ■

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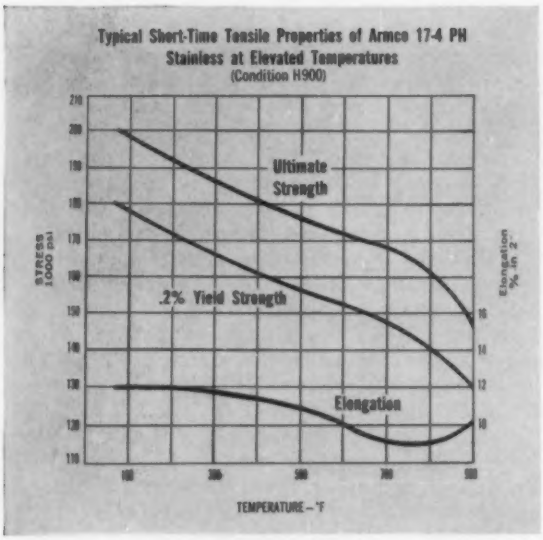
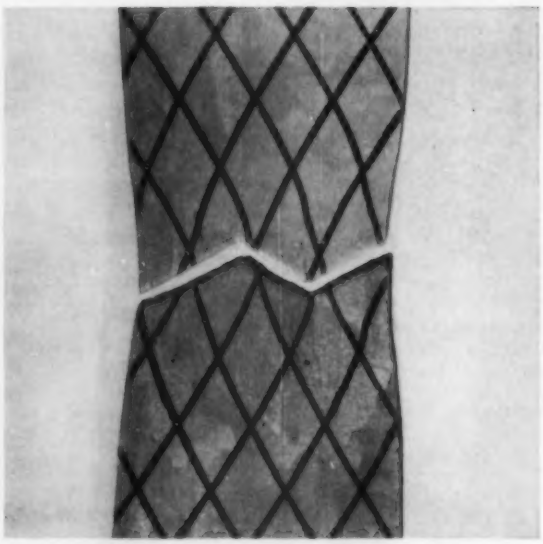
Here's Why These Armco Can Help You Reduce Costs,



Armco 17-4 PH Stainless Steel Bars

Take a close look at the typical mechanical properties of this Armco precipitation-hardening stainless steel. The combination of excellent corrosion resistance, comparable to that of Type 302 stainless, and high hardness and strength up to 900 F, offers an economical solution to many problems.

Armco 17-4 PH is being widely used by manufacturers of fasteners, pumps and valves, chemical and food processing equipment and a wide range of specialty products. An added advantage: Armco 17-4 PH Stainless is hardened at only 900 F. This one-hour heat treatment eliminates descaling, straightening and finishing operations.



Armco ZINCGRIP® Steel

Fractured tensile test specimen of Armco ZINCGRIP® Steel is cross-hatched to show metal flow. It demonstrates that the full weight hot-dip zinc coating won't flake or peel even when the metal is stretched 60-70% and broken.

This means you can give your products economical overall protection against rusting. There's no need to worry about flaking or peeling of the zinc coating, no matter how severe the forming operations. For only a few cents' premium over cold-rolled steel, you can often eliminate the cost of painting or plating parts. Used for more than 20 years, Armco ZINCGRIP Steel has shown it can cut costs and improve performance. Supplied in sheets and coils.

ARMCO STEEL CORPORATION
1580 Curtis Street, Middletown, Ohio

Please send me information on
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- ☐ Armco ZINCGRIP Steel
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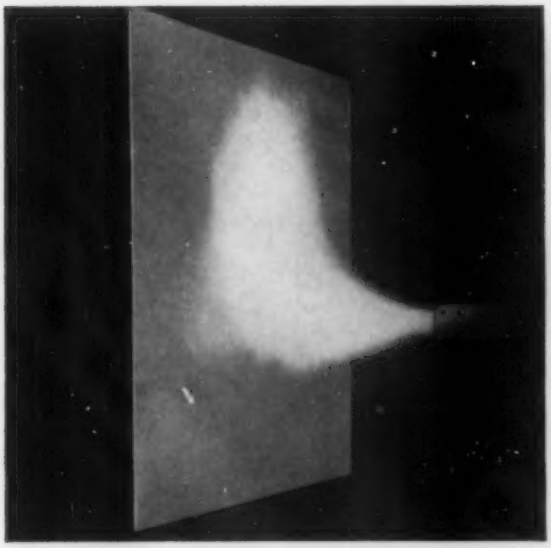
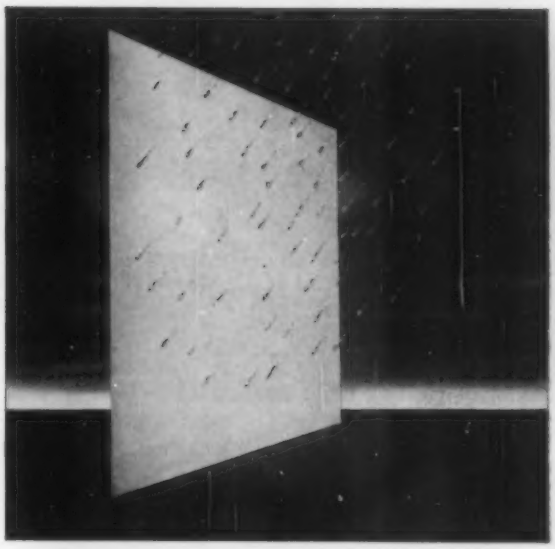


Armco Aluminized Steel Type 1

The extraordinary ability of Armco Aluminized Steel Type 1 to resist heat and a combination of heat and corrosion may help you. This Armco-developed special steel combines the strength of a steel base with a hot-dip aluminum coating that provides good heat reflectivity, as well as resistance to oxidation and corrosion. No other metal in its price class offers the advantages of Aluminized Steel Type 1.

It is unmatched in economical durability for gas- and oil-fired heat exchangers and combustion chambers, automobile and truck mufflers, drying ovens, appliance parts, and similar applications.



Armco Aluminized Steel Type 2

Outstanding advantages of this special Armco Steel are its lasting protection against atmospheric corrosion and its low cost. The unique hot-dip aluminum coating provides lasting rust-resistance; the steel base assures adequate strength and rigidity. Corrosion tests and service prove that the coating on Type 2 Aluminized Steel sheets outlasts unpainted galvanized sheet coatings by at least 3 to 1.

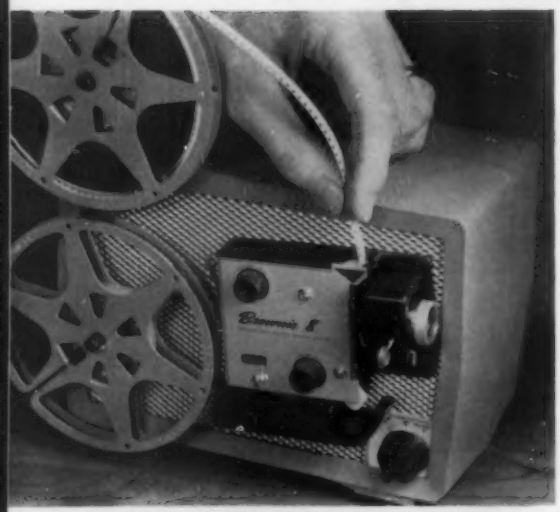
For siding, equipment covers, sheathing, ventilators, roof decking, agricultural equipment and other products exposed to the atmosphere, this special Armco Steel assures long service life at minimum cost. Aluminized Steel Type 2 is available in sheet and strip in a wide range of gages.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

CIRCLE 23 ON READER SERVICE CARD

Budget camera equipment with deluxe features may provide



Inexpensive motion picture camera, above, has simpler, more integrated appearance than most of its more costly relatives. Large, easy-to-read symbols graphically indicate light conditions that govern aperture settings. Shutter release bar is big enough for two-finger actuation, which means that both hands can be used for camera support. Wind-up lever on left side unfolds away from housing to provide sizable, comfortable crank, instead of usual key. Optical unit, threading device and reels of projector are mounted on expanded aluminum grill that also permits fan-forced through-cooling. Case is painted phenolic.

Too bad fussy case of current Brownie line was retained for new model, left, whose combination unit of built-in exposure meter and view finder has appropriate simplicity, typified by flush mounting of exposure dial on top surface. F/8 lens can take either black-and-white or color, and can also be used with flash.

industry breakthrough

■ With a movie camera priced under $25, a still camera with built-in photo-electric exposure meter at about $20, and a self-threading projector at little more than $50, Eastman Kodak Co has provided the basis for a possible breakthrough of highly gadgeted photographic equipment into the big low-priced field, where this veteran of the industry got its start. The famous brand name, "Brownie," now has been applied to an 8mm, f/2.7 movie camera. Even accessories for this camera are low in cost—a plug-in double light unit is less than $6.

The new projector has an f/1.6 lens and a device that automatically threads film on a 200-ft take-up reel. Pull-down claw and a fixed film-guide assembly operate as soon as film is introduced into projection gate. Projector need not be lifted or lowered to center picture on screen because a knob control changes angle of optical system itself.

Readings of built-in exposure meter are translated to one of five shutter settings by means of a large dial on top of case. Shutter is synchronized for use with all popular flash bulbs, including new jelly-bean size, the AG-1.

Other new Eastman Kodak products—not budget-priced, but announced at the same time and also likely to have lasting effects on the industry—are shown at right. Industrial design consultants for Eastman are Walter Dorwin Teague Assoc, New York. ■

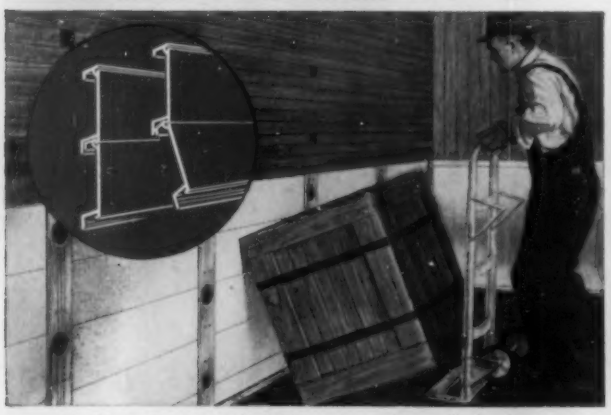
Tape-and-slide programmer, above, and 8mm projector, below, are not part of new budget-priced Eastman Kodak product group shown at left, but they may also open up new market areas. Programmer can synchronize home-recorded audio program with slide projector. Once tape is completed and programming finished, slide sequence with audio material can be shown automatically. Trip signals that change slides are inaudible.

Projector is equipped to record, on home or industry-made movies, a running commentary, music or other material. To do this, a magnetic oxide strip must first be added to film edge.

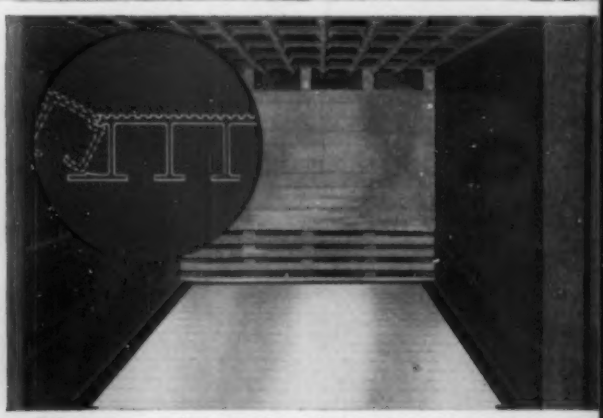
HOW ALUMINUM IMPROVES PRODUCTS, LOWERS COSTS

...in railroad equipment, for instance

Reynolds Aluminum bodies in new hopper and gondola cars raise payload capacity 5 to 10 tons per car depending on product density.



Lightweight, rugged freight car inner-liners of aluminum extruded panels upgrade and extend car life, won't rust.



Refrigerator car flooring of interlocking Reynolds extrusions is water-tight, built to outlast three wood floors.

A new design idea or material really has to *prove* itself through vigorous testing before it is adapted for use by the railroad industry. That's why the recent trend towards increased use of Reynolds Aluminum in railroad equipment is so significant. It means that aluminum is winning acceptance in another major industry—an industry which demands maximum service from its materials and equipment.

You may not be directly concerned with the design of railroad equipment, but chances are, the same properties that are paying off for rail operators and shippers could benefit your product or production, too.

For example, weight savings: A large railroad recently ordered 1,200 new hopper and gondola cars with bodies of Reynolds Aluminum. This use of aluminum cuts enough dead weight off each car to enable it to carry *5 to 10 tons more payload* (depending on product density) than the same size steel car.

Aluminum's strength and corrosion-resistance really pay off in freight car inner-liners. These rustfree aluminum liners need no painting for protection against corrosion or rust. They take a real pounding from freight and loading, weigh a third less than steel liners.

Aluminum can't rust, rot, warp or splinter. That's why aluminum flooring will outlast three ordinary refrigerator car floors made of wood. Reynolds Aluminum flooring, designed in 10-inch wide interlocking extruded panels, is water-tight, strong, easy to clean, and designed for the life of the car.

Lightweight strength of aluminum crossmembers saves time and labor, prevents freight damage. Weighing just 47 lbs. compared to about 70 lbs. for wood and steel types, aluminum crossmembers are easily handled by one man. They hold the heaviest loads, last longer, too.

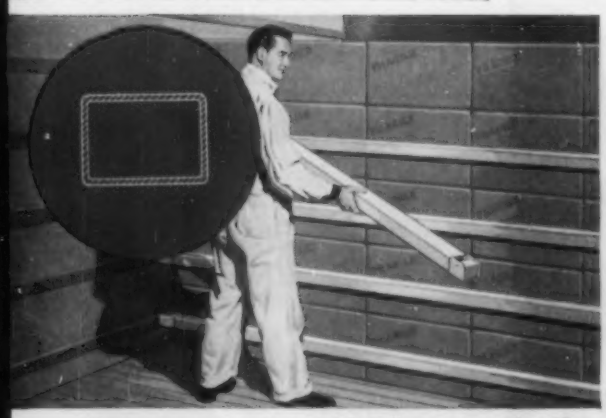
Low maintenance requirements and light weight make aluminum a "natural" for box car doors. They won't rust; they need no painting. And because they're lighter and easier to operate, they cut labor, reduce chance of damage.

These are just a few examples from one field. Reynolds Aluminum is doing the same job in hundreds of industries, in countless products. If you want to make a product lighter with no sacrifice in strength, more corrosion-resistant, rust-free, and lastingly attractive, consider aluminum.

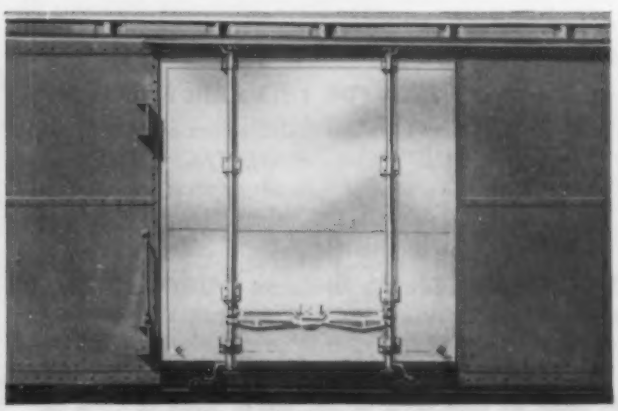
For technical data and details on the properties, availabilities and possibilities of aluminum, call your local Reynolds office, or write *Reynolds Metals Company, P.O. Box 2346-HN, Richmond 18, Virginia.*

REYNOLDS ALUMINUM

Watch Reynolds TV shows—"ALL STAR GOLF", "BOURBON STREET BEAT" and "ADVENTURES IN PARADISE"—ABC-TV



Aluminum crossmembers weigh 47 lbs., compared to 68 lbs. for wood-steel types, cut labor, last longer.



Box car doors of Reynolds Aluminum are easily operated by one man because they're lighter; they need no painting.

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CLUTCHES

READER TO EDITOR

Exception Doesn't Prove the Rule

To the Editor:

Your "tangents", (Feb 15, p 143) was enjoyed but we take very definite exception to your quote "the exception that proves the rule". Our experience has been (and it has been shared by many others) that we know of no exception that proves any rule.

—JOHN J SNOWDON
General Electric Co
Philadelphia

• This quote probably dates back to a statement by Robert Burton in "Anatomy of Melancholy," written in the early 17th century: "No rule is so general, which admits not some exception." In any case, it is quite a familiar dialect phrase. The difficulty with it is based on the definition of the word "proves." You will be astonished to find that your definition is the third one listed in Webster; "to demonstrate or show." The first meaning is: "To try or to ascertain by an experiment or by a standard; to test; now especially to subject to a technical testing process, as to prove cannon, gold or coal." I suppose the expression might be modified to "the exception that tests the rule," to overcome the confusion.—EJT

Another Look at Creativity

To the Editor:

I was enormously impressed with your editorial and your report on creativity. Once or twice I almost got the feeling that some of those Harvard conferees might have been "reading my mail!"

Your article seemed to cover the subject very thoroughly—just this side of entirely complete. There are but two points the Harvard session seemed to neglect. (1) I think there must be some connection between manual dexterity and the creative mind. Da Vinci, Franklin, Kettering, Michelson, and others highly skilled in use of their hands, seem also to have developed a high degree of creativity. But perhaps as many examples, or more, could be given of highly creative people who had no manual dexterity. I don't know. (2) Perhaps creativity is just a result of having a mind of extremely superior logical capacity. In this case, is the manual dexterity just a result of the logic, as is creativity—just something incidental?

I don't think that creativity can only be a result of the logical mind. I hold that if we could set down, as a result of analysis, the basic, fundamental, indivisible parts of any problem that faces us, the chances are close to 100% (if not actually 100%) that the course of action would be immediately obvious. Trouble with most creativity—reason for slowness, waste of manhours, and poor results—is that the initial analysis of the problem is incomplete. What are all the details, the *minute* details, of what you are trying to do? Ditto, in all the different gadgets you know of; how do they fail in achieving that? . . .

I was impressed also with reader reaction to your article, and amused by the guy who

continued on page 30

A BUILT-IN SALES ADVANTAGE FOR YOUR PRODUCTS, TOO

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This new and *integral* finish not only spurs product sales . . . it cuts costs, too. Can be laminated permanently to metal. Texture and color remain unimpaired by forming, crimping, stamping, drilling, etc. No new equipment required. Can even eliminate the need for spray booths, and baking ovens. Cleans easily. Mail coupon for samples.

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CIRCLE 29 ON READER SERVICE CARD 29

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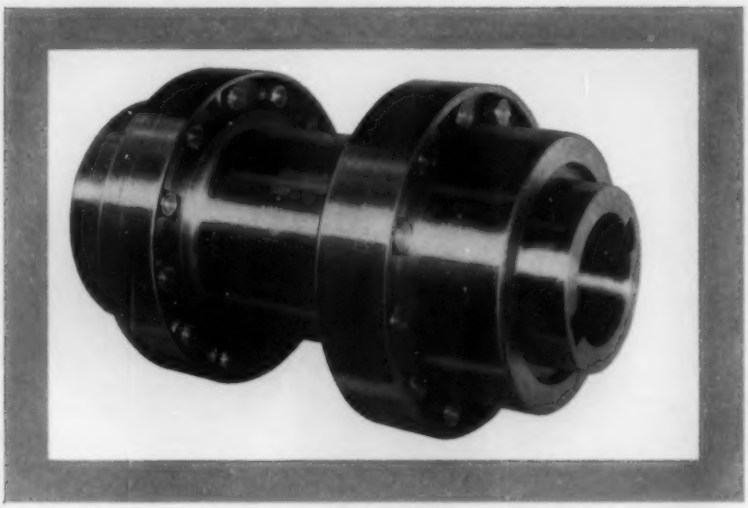
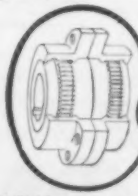


That's why all Waldron high speed coupling forgings (of SAE 4140) are "rough machined" to +.001", —.000", and then hand finished (sleeves first, then hubs). Bolts and nuts are weigh balanced, and the assembled coupling dynamically balanced as a unit—then match marked for reassembly.

Waldron high speed couplings are now operating at speeds of 70,000 rpm and more, and in drives up to 48,000 HP.

Even if your requirements don't involve such demanding service, it's good to know you have an extra margin of safety and reliability when you specify Waldron High Speed or any Waldron Coupling.

WALDRON  **Couplings**

WALDRON-HARTIG DIVISION *Midland-Ross Corporation*
P. O. Box 791 · New Brunswick, New Jersey

came up with so many new inventions in one short, few hours' space. I couldn't work that fast, although occasionally Patent Offices have declared me an inventor, *legally*. But I agree that creativity isn't always a young man's game. Much of my time in over 20 years has been in research and development in ultraprecise circle-dividing (error-limit less than ½ arc sec). The first 5 years (in one's 40's), research—collecting data, study and analysis of the problem. Then more than 15 years' development—"inventing," with the resulting dividing engine progressively more different from all others (whose basic inhibitory factors limit possible production accuracy to 0.6 arc sec). Of this time, 10 years developing something sufficiently different to assure productive error-limit of 0.4 arc sec. But the accomplishment of the final 2 years (in one's 60's) appears greater than all the rest: The last, most difficult bits of the development puzzle seemed to fall into place; and the calculated error-limit is 0.1 arc sec.

—Lew Suverkrop
ME Consultant
Bakersfield, Calif

COMING EVENTS

MARCH

29-31 . . . . American Society of Mechanical Engineers, American Power Conference, Hotel Sherman, Chicago.

APRIL

4-8 . . . Nuclear Congress and Exhibit, New York Coliseum, NYC.

5-8 . . . Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, NYC.

5-14 . . . . International Spring Technical Fair, Utrecht, Netherlands.

6-8 . . . Institute of Environmental Sciences, 1960 National Meeting, Biltmore hotel, Los Angeles.

7-8 . . . American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, NYC.

18-19 . . . . Joint Conference on Automatic Techniques, Sheraton Hotel, Cleveland.

19-21 . . . . American Society of Lubrication Engineers, Annual Meeting and Exhibit, Netherland-Hilton Hotel, Cincinnati.

20-22 . . . . Institute of Radio Engineers, 1960 Southwestern Conference and Electronics Show, Shamrock-Hilton Hotel, Houston.

25-29 . . . . American Society of Mechanical Engineers, American Welding Society, Annual Meeting and Welding Exposition, Biltmore Hotel, Los Angeles.

26-27 . . . . Westinghouse Machine Tool Forum, Conrad Hilton Hotel, Pittsburgh.

Naugatuck KRALASTIC®

KRALASTIC "cap" saves retightening 5,000 bolts!

The five thousand bolts required for the installation of each A. O. Smith glass-lined silo must be as resistant to silage juices as is the glass coating itself.

Ceramic-coated bolt heads proved both costly and brittle. Bolts capped with stainless steel were even more expensive and, like the ceramic-headed bolts, required asbestos washers to effect a proper seal and prevent damage to the glass lining. Certain plastic materials, including nylon, gradually loosened as a result of cold flow, required later retightening of every single bolt!

Capping the bolts with KRALASTIC MM solved all. Easy to apply and relatively inexpensive, the tough KRALASTIC cap needs no washer. It has exceptional chemical resistance and because of its very high resistance to cold flow, it eliminates the "nutty" problem of retightening 5000 bolts per silo.

In short, KRALASTIC proved to A. O. Smith, as it has to *hundreds* of manufacturers, that its unique combination of properties can produce better products at less cost in applications by the thousands.

Satisfied with *your* product? Why not investigate the possibilities this versatile rubber-resin compound offers you.

United States Rubber
Naugatuck Chemical Division
330 K ELM STREET
NAUGATUCK, CONNECTICUT

KRALASTIC RUBBER-RESINS • **MARVINOL** VINYLS • **VIBRIN** POLYESTERS

Akron · Boston · Chicago · Gastonia · Los Angeles · Memphis · New York · Phila. · CANADA: Naugatuck Chemicals · Elmira, Ont. · Cable: Rubexport, N.Y.

CIRCLE 31 ON READER SERVICE CARD 31

Custom electronic cables shielded or jacketed in seconds!

SHIELDED ZIPPERTUBING®

Zippertubing® lets you make custom cables **anywhere, any time** without the aid of machinery or other equipment. You get 100% shielding coverage of wires, cables, and branch-out cable assemblies. One inexperienced man can do the job in **one easy, timesaving** operation! Cables can be permanently sealed or simply zipped closed for easy re-accessibility to conductors.

ZIPPERTUBING® NOW AVAILABLE IN MATERIALS TO MEET EXTREME TEMPERATURE AND USE CONDITIONS . . . Zippertubing is available in aluminum, copper, or co-netic steel. These conductive metals are combined with vinyl, Teflon, Mylar, Nylon or fiberglass for abrasion resistance. There is also Zippertubing to stand up against nuclear rays and Thermazip for the extreme temperatures of missile blast.

ZIPPERTUBING® MEETS MIL SPECS. If you design or work with electronic cables, it will pay you to investigate Zippertubing. Send for free literature and the name of your closest field representative.

Pat. and Pat. App. For

THE Zippertubing® CO.
752 S. San Pedro St., Los Angeles 14, Calif.

FOR YOUR INFORMATION (personal)

Hot wrists?

If you want to know the temperature round your wrists or rib cage, Zinn Originals, 321A Greenwich St, New York 13, has just the thing for you: cuff links and a tie clasp with real, miniature oven-type thermometers, said to be accurate to within one degree. Price, silver or gold plate, $7.50 the set; separately, $2.75 for the tie clasp alone, $5.50 for the paired cuff links.

New plastic makes self-closing doors

Aluminum storm-screen doors that "shut themselves" represent one of the first large-scale consumer applications for the magnetic plastic strip announced last year by B F Goodrich Co (*PE*—May 4 '59, p 11).

First used on refrigerator doors, the material is extruded vinyl plastic incorporating a magnetic powder.

The storm-screen-door application, which is similar to that on refrigerators, bears a close resemblance to weather stripping. One strip of the plastic is a channel inserted on the latch side of the door; a matching strip on a jamb liner is fitted to the outside door casing. Weather-Seal Inc, Barberton, Ohio, is the door manufacturer.

Polystyrene for your wall?

Planning to install some of those pretty plastic wall tiles in your house? Before you do-it-yourself, take a look at the revised appendix to the US Dept of Commerce Commercial Standard.

For best results, the addendum says:

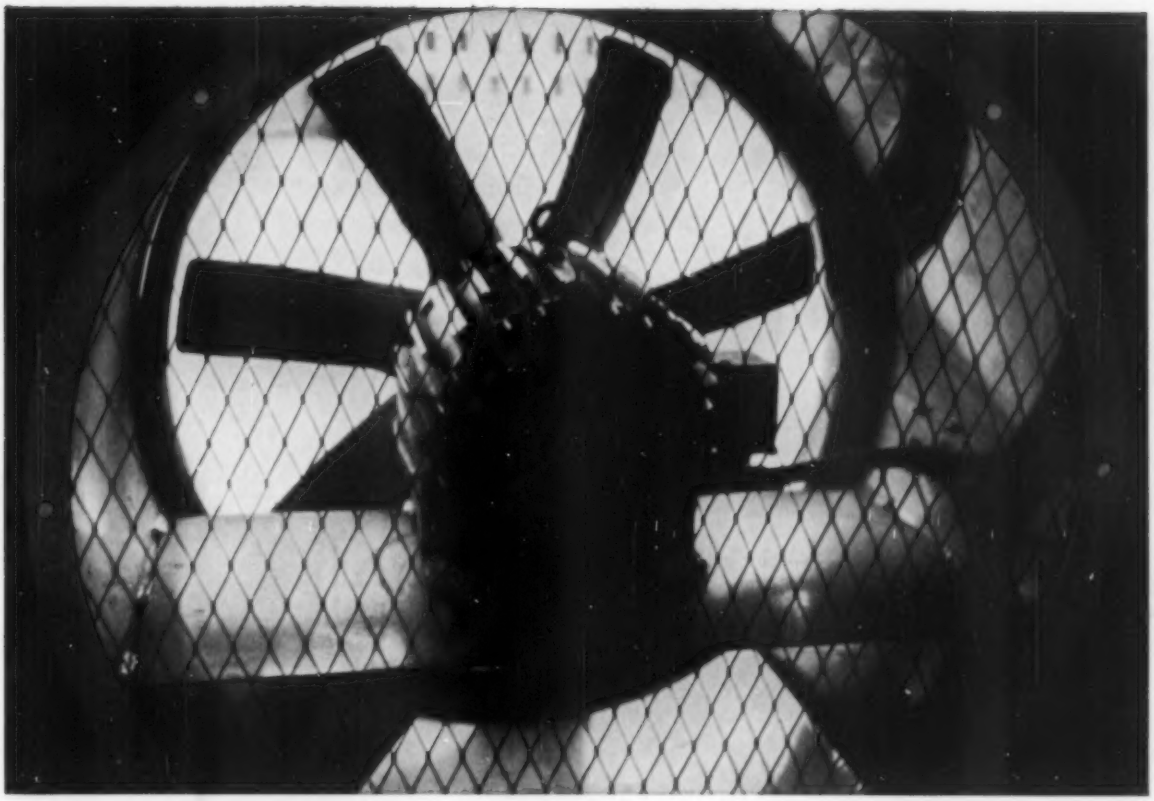
- Room, wall tile, and adhesive should be kept at a minimum of 60 F for 24 hr before and 72 hr after application.
- All adhesives should be clean and thoroughly mixed to a uniform composition.
- Walls should be straight, even, clean, dry, and free from high or low spots. All corners should be square and plumb.

That's only the beginning, of course. There are a dozen rules for application; and then, when you get the tiles on, you'll want to be sure they're shielded against contact with vinyl plastics (shower curtains, for instance), protected from heat, and washed with the proper compounds.

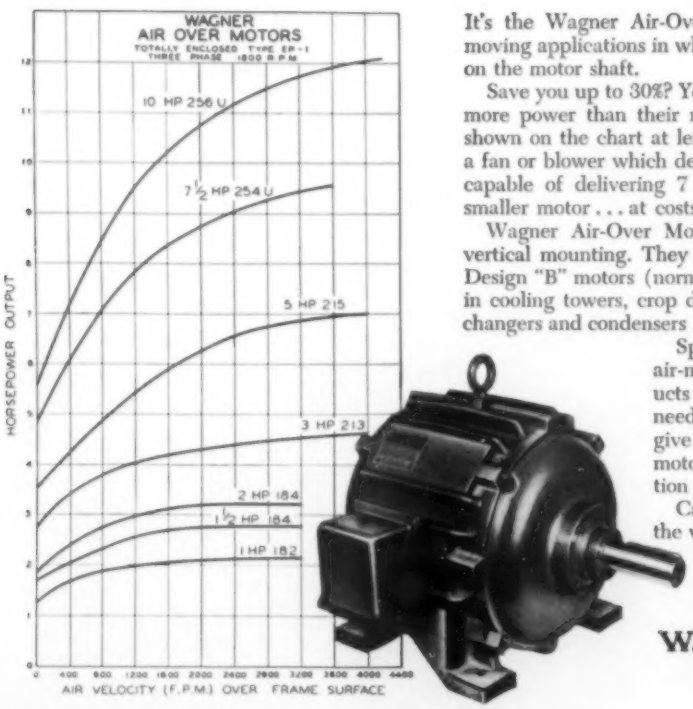
Hear the sea as you drive

A transistorized converter for car radios, making it possible to tune in on marine frequencies, is being made by Hartman Marine Equipment Corp, Long Island City 1, N. Y. Priced at $19.95, it has two tuned stages of preselection ahead of the transistor oscillator-mixer, to eliminate broadcast feed-through. This, in effect, turns the broadcast dial of the car radio into an intermediate-frequency section. The unit is 5 in long x 2¼ in wide, weighs 10 oz.

Coming up soon: a similar unit that can be used for tuning in on aircraft frequencies. —ARG



This Wagner Motor can save you up to 30% in costs on air-moving equipment



It's the Wagner Air-Over Motor . . . *specifically* designed for air-moving applications in which a propeller or axial flow fan is mounted on the motor shaft.

Save you up to 30%? Yes, for Wagner Air-Over Motors can deliver more power than their rated horsepower output. For example, as shown on the chart at left, a 5 horsepower rated motor installed in a fan or blower which delivers about 4,000 feet of air per minute is capable of delivering 7 horsepower. You get more work from a smaller motor . . . at costs up to 30% less.

Wagner Air-Over Motors are suitable for either horizontal or vertical mounting. They are totally-enclosed, nonventilated NEMA Design "B" motors (normal torque—normal slip). You can use them in cooling towers, crop dryers, exhaust systems, air-cooled heat exchangers and condensers . . . any air-over fan and blower application.

Specify Wagner Air-Over Motors for all your air-moving equipment applications. Your products will operate at peak efficiency for years, need less service and fewer repairs. And, you'll give your customers equipment powered by motors they know . . . motors that have a reputation for long, dependable service.

Call your Wagner Sales Engineer now . . . get the whole Wagner Air-Over Motor story. There are Wagner Branches in 32 principal cities across the country.

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 33, Mo.

WM60-13

CIRCLE 33 ON READER SERVICE CARD

CIRCLE 34 ON READER SERVICE CARD →

NS SPECIAL WIRE KEEPS SPRINGS ALIVE IN 1400° BATH

When a leading manufacturer of microwave assemblies and radar components was faced with a serious production bottleneck in a high-temperature dip-brazing operation, they came to National-Standard for help in solving the problem.

CRITICAL MICROWAVE ASSEMBLIES being brazed in a 1400° salt bath were held together by cumbersome weights and intricate fixtures that frequently caused distortion or slippage during the brazing operation. The solution—and a considerable time and money saver—was to clamp all the components with springs that would allow expansion of the various parts during brazing without distorting the assembly. However, conventional spring wire would not retain tension at 1400°. Once used, springs had to be discarded.

NATIONAL-STANDARD ENGINEERS, working with the manufacturer's engineers, tested a new superalloy spring wire, NS-25 (L605), that proved "as good as new" after several hundred brazing operations at 1400° F. The mechanical stability of NS-25 spring wire insures proper expansion of parts during heating and maintains just the right tension to give mating parts good contact and perfect bond. The result is manufacturing that is simplified, faster and more precise than was previously possible.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

MICROWAVE ASSEMBLIES are held together in 1400° brazing bath by springs made of NS-25 wire. This special alloy wire allows rapid, precise brazing never before possible.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

FOR SEMS...BUY P-K®

All Types of SEMS and Pre-assembled Fastener-Washer Combinations

Whatever you require in pre-assembled washers... SEMS, and neoprene or nylon washer STAPS®... in thread-forming and thread-cutting tapping screws, or machine screws... with slotted, Phillips or Hex heads... P-K can supply them all through your local P-K Distributor.

P-K SEMS reach your assembly line pre-assembled, ready for instant use. Washers cannot come off—can never be mislaid or misplaced—insures washers on screws...not on the floor! Double inventory and double parts handling is completely eliminated.

P-K SEMS can be hopper fed for automatic driving. Inspection rejects due to omitted lock washers are impossible—fastenings stay tight and firm. P-K Sems assure concentric washer seating.

STAPS® are standard P-K fasteners, pre-assembled with nylon or neoprene washers for effective control of leaks, squeaks, crazing and electrolysis, in all types of metal structures and assemblies.

Your nearby P-K Distributor can meet your needs. Call him for samples and complete information.

PARKER-KALON® fasteners

Keep American Industry at Work . . . Buy P-K . . . made in U.S.A.

PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.

d'ARAZIEN

Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

**The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.*

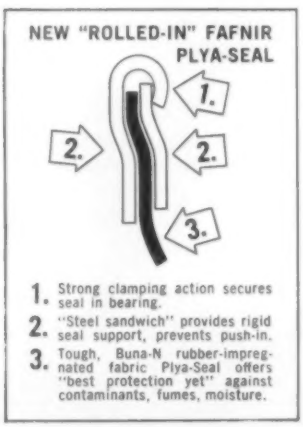
Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

Fafnir's new "seal in a steel sandwich" stays put . . . resists push-in . . . improves protection!


NEW "ROLLED-IN" FAFNIR PLYA-SEAL
1.
2.
2.
3.
1. Strong clamping action secures seal in bearing.
2. "Steel sandwich" provides rigid seal support, prevents push-in.
3. Tough, Buna-N rubber-impregnated fabric Plya-Seal offers "best protection yet" against contaminants, fumes, moisture.

Notice the steel supports on both sides of the seal in this Fafnir ball bearing. Notice, too, that the seal is held by clamping action from the rolled-in, firmly wedged supporting members.

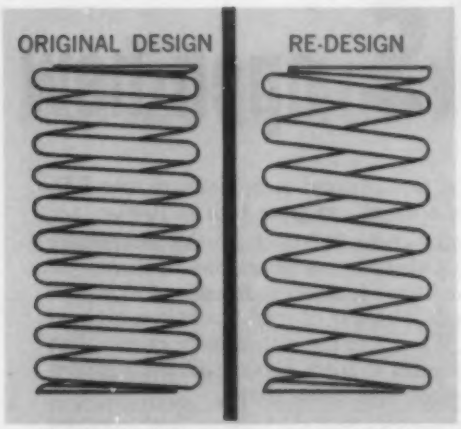
This new Fafnir seal design is specifically engineered to prevent seal push-in, and to assure positive anchoring of the seal in the bearing. Protection against contaminants is increased... lubricant is more effectively locked in the bearing. Sealing is further improved by the "baffle action" of the inner steel support, and the lip-in-groove design of the seal itself.

Fafnir ball bearings with new, "rolled-in," nonremovable Plya-Seals are now available in a wide range of sizes and in Fafnir power transmission units. Write for complete data. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120" wire
130 lbs. of wire per
1M springs

7 coils—.105" wire
60 lbs. of wire per
1M springs

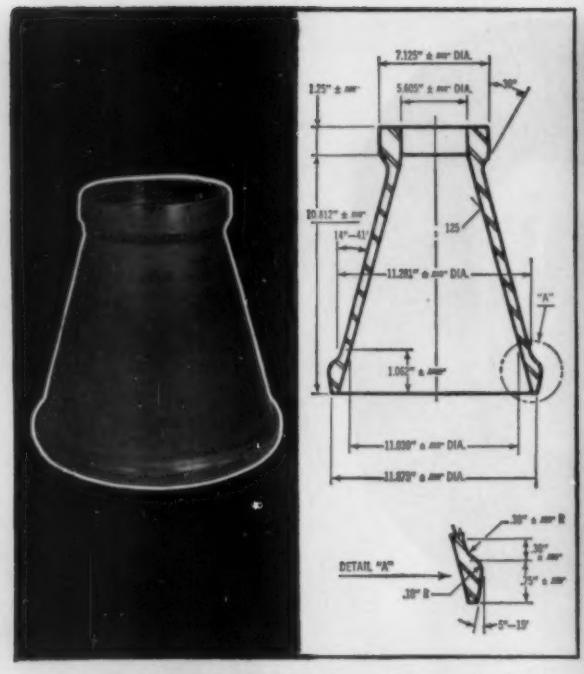
Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

How about the springs you use? A consultation on your specifications costs you nothing. Just contact any Division of Associated Spring Corporation. For a handy reference to spring action, write for "Spring Design and Selection—in brief."

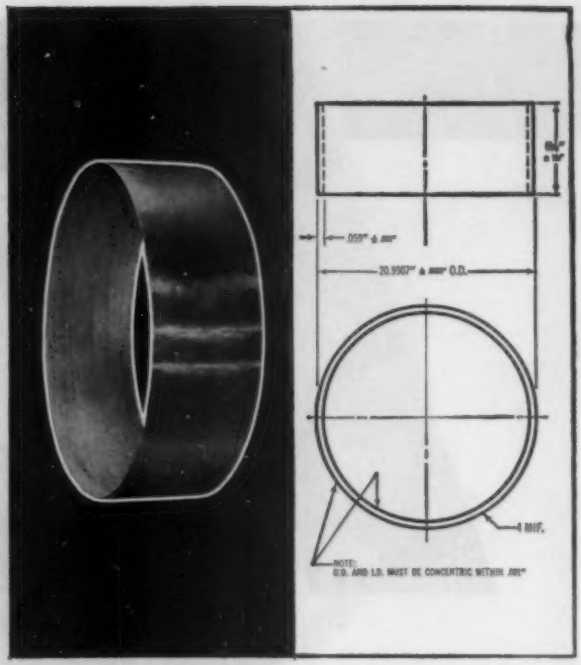
Associated Spring Corporation General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.



STRAIGHT SIDE ROCKET CONE—Spun with tapered wall from 1020 steel blank: 18" diameter, 1" thick. Inside surface 125 MIF.



STRAIGHT WALL TUBE PRINTING BAND—Spun from ⅛" thick aluminum to .060" wall thickness, outside surface machine finished to 4MIF.

ROTOFORMS open new

ROTOFORMING reduces cost of unusual metal shapes—saves metal, eliminates machining and surface finishing

The design possibilities for hollow metal shapes are now unlimited. The most unusual metal custom parts can be practically and economically produced by ROTOFORMING.

This revolutionary new metal forming service now being offered by COMMERCIAL SHEARING & STAMPING displaces metal in a blank or preform. Rollers contacting the outside surface of the metal form it by high pressure as it rotates around a mandrel. The shape of the mandrel itself, at all times, controls the inside contour and size of the part.

WHAT SHAPES ARE POSSIBLE? Basically, ROTOFORMS can be grouped into four main categories: Straight-Side Cones, Straight-Wall Tubes, Curvilinear-Wall Shapes, and Elliptical or Hemispherical Shapes. Pictured above are representative ROTOFORMS already produced by COMMERCIAL. Principal dimensions are included.

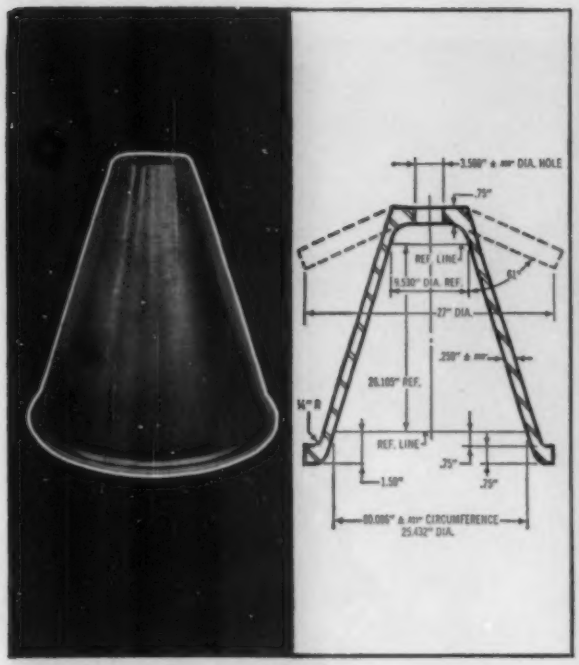
WHAT ABOUT SIZE AND WALL THICKNESS? The range of sizes for ROTOFORMS covers maximum diameters up to 42" down to a minimum tube I.D. of 2¼". Tube length can go as high as 100".

Steel blanks up to ¾" thick can be successfully handled by ROTOFORMING where conical shapes are involved. And when it comes to forming straight-wall tubes the wall thickness of steel blanks can even go up to ⅝". When forming metals more ductile than steel it is possible to work blanks with even greater wall thicknesses than those above.

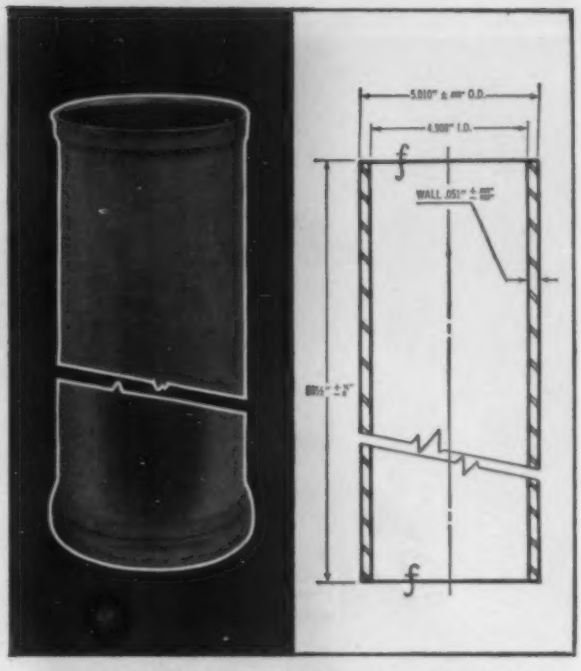
With ROTOFORMS wall thicknesses—both constant and variable—are feasible. Walls referenced to C/L can be straight, curved, or tapered. And ROTOFORMS have been successfully produced with a finished wall thickness no greater than 1/32".

WHAT METALS CAN BE ROTOFORMED? A wide variety of carbon steels, stainless and special alloy steels, as well as aluminum, nickel, copper, molybdenum, magnesium and titanium alloys can be successfully ROTOFORMED. Even metal alloys such as 4130 steel, 1100-0 aluminum, and hard to machine Hastelloy, can and are being used in the regular production of ROTOFORMS.

WHAT HAPPENS TO THE METAL? The plastic deformation which metals undergo in the ROTOFORMING process elongates their grain structure and sub-



STRAIGHT SIDE MISSILE EXIT CONE—Spun with constant wall thickness from press pre-formed 1040 steel blank: **29" diameter, ¾" thick.**



STRAIGHT WALL ROCKET TUBE—Spun from 4135 steel tubing (wall thickness ½") reduced to finished wall .051".

horizons for metal shape design!

stantially increases their strength. Tensile increases 1½ to 2 times, yield point is raised in even higher proportion, and fatigue strength is substantially improved. And ROTOFORMED parts can be heat treated to increase their ductility.

Because of the plastic deformation of metal, involved weld joints become unnoticeable when ROTOFORMED. And there are no hidden metal flaws in ROTOFORMS. Any metal inclusions or flaws in the parent metal are quickly uncovered during the ROTOFORMING process—appear as ruptures when pressure spinning rolls reposition the metal by physical displacement. Only 100% sound metal will produce successful ROTOFORMS.

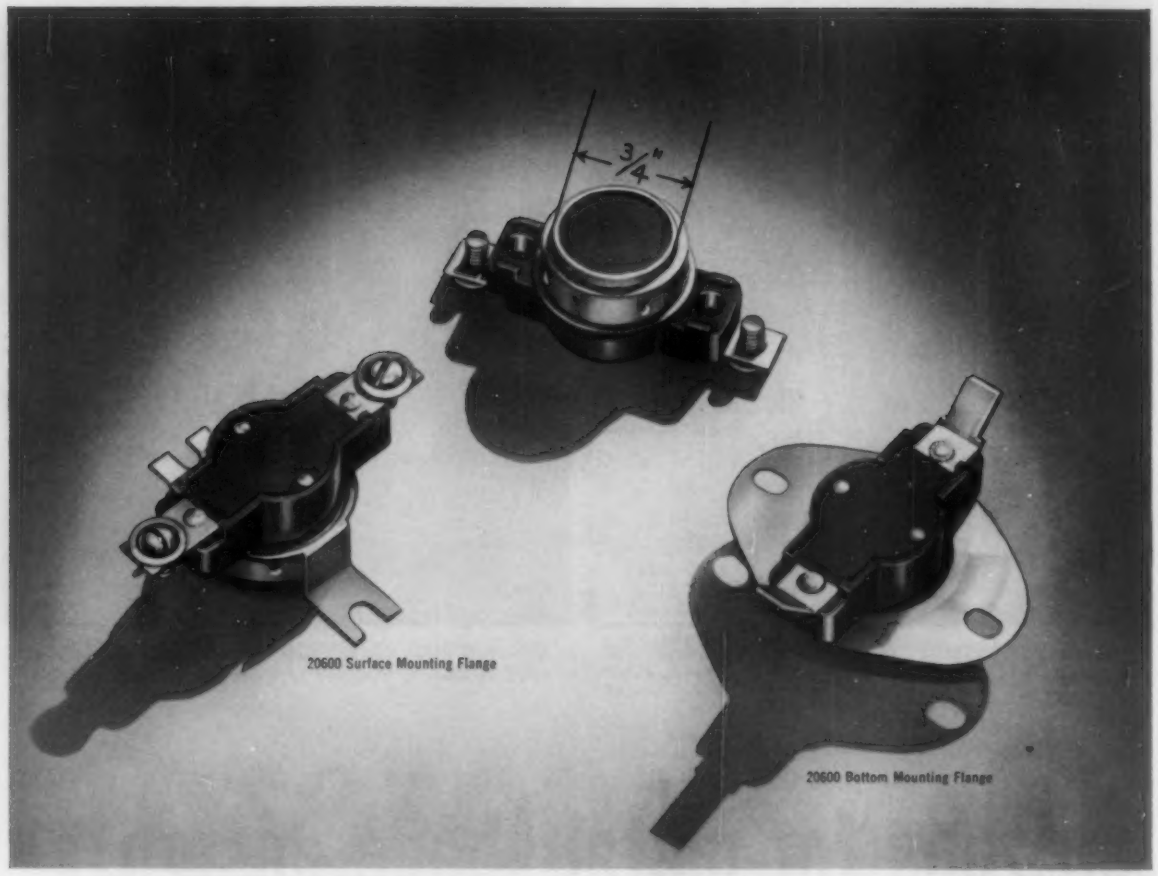
WHAT ABOUT TOLERANCES AND FINISHES? Extremely close tolerances and tolerances commonly associated with fine machining are routine in the production of ROTOFORMS. It is not uncommon for ROTOFORMED parts taken from the machine as is to have inside diameters held to tolerances of +.000" –.003", +.005" –.000", and +.005" –.005".

Inside areas of ROTOFORMS finish to a glass-like surface—30 to 60 micro inch finishes being well within standard production practice. While outside surfaces finish to about 125 micro inch.

Because dimensional tolerances and inside surface finish have a direct relation to the variation and finish of blank from which the ROTOFORM is produced, when necessary the tolerances of a blank can be reduced and its finish improved beforehand in order to provide closer tolerances and a better inside finish in the actual ROTOFORM. In addition, the outside surfaces of ROTOFORMS can be brought to smoother finish by grinding, polishing or fine machining.

AN INVITATION FROM COMMERCIAL! This new metal forming process could be the practical and economical answer to your particular component problem. You can find out very quickly. Just a blueprint, sketch or prototype of your part in the hands of our engineers will bring you the complete cost-saving story—and at no obligation. Address inquiries to Commercial Shearing & Stamping Co., Dept. G-14, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

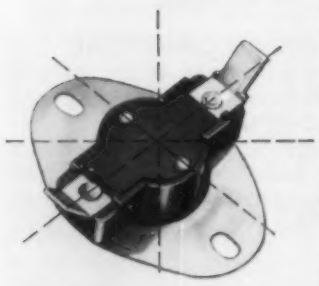


NEW KLIXON® 3/4" THERMOSTAT

FEATURES

Smaller Size and Better Performance at Lower Cost

New Mounting Versatility



Terminal axis can be positioned with respect to flange axis to provide maximum electrical clearance in mounting.

The new ¾" KLIXON 20600 Series Thermostats offer users high quality performance as operating and limit controls in a variety of appliance, heating, and general purpose applications.

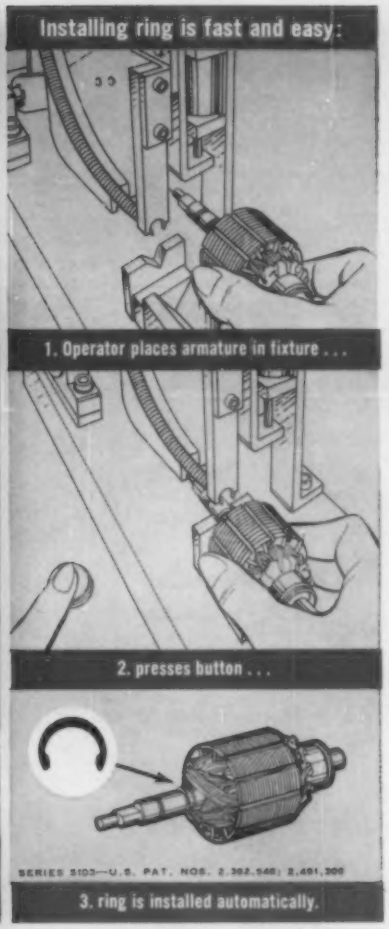
Although relatively small in size, they have heavy duty electrical capacity . . . up to 25 amps., 240 VAC resistive. U/L approved at 100,000 cycles. Switch action is clean and dependable even when subjected to shock and vibration.

The KLIXON 20600 Thermostats are available in automatic or manual reset types with bottom or surface mounting flanges.

Our Field Engineers will gladly help you make test applications. Write for technical data bulletin THSN-23, which gives complete performance characteristics, temperature setting information and dimensions.

TEXAS INSTRUMENTS
INCORPORATED
METALS & CONTROLS DIVISION
3603 NORTH MAIN STREET • VERSAILLES, KENTUCKY

VERSAILLES PRODUCTS: Klixon® and Ampli-Tube Thermostats


Installing ring is fast and easy:
1. Operator places armature in fixture . . .
2. presses button . . .
SERIES 5103—U.S. PAT. NOS. 2,362,548; 2,491,300
3. ring is installed automatically.

Mechanized Truarc ring installation speeds assembly

eliminates costly shimming and gauging operations

Fast, semi-automatic assembly and the elimination of costly production operations are among the benefits Leece-Neville Co., Cleveland, Ohio, derives from the use of Truarc retaining rings in the manufacture of its fractional horsepower automotive motors.

Radially-assembled Truarc Series 5103 Crescent® rings—supplied pre-stacked—are used to position and lock the armature in the motor housing. Using the special Truarc pneumatic applicator-dispenser illustrated above, the operator merely inserts the rotor and presses a release button. The ring is installed automatically in a pre-cut groove on the rotor shaft!

The precision manufactured Truarc rings, seated in accurately located grooves, reduce accumulated tolerances from a possible maximum of .184" to .025". Costly, time-consuming shimming operations previously necessary to take up end play are eliminated, together with as many as four gauging operations required to select and place the shims.

The Leece-Neville story is just one example of the way Truarc retaining rings are stepping up production on today's fast-moving assembly lines. These versatile fastening devices simplify design, speed assembly and eliminate rejects. In replacing conventional fasteners, they often improve product performance and reliability. All of these advantages are in addition to substantial cost savings!

Truarc retaining rings come in 50 functionally different types . . . up to 97 different sizes within a type . . . 6 metal specifications and 13 finishes. Special Truarc hand, magazine and automatic applicators and grooving tools make production-line application easy on virtually every type of product. Make sure you have on file the new 16-page Truarc assembly-tool catalog No. AT 10-58. Write for your copy today. And remember Waldes Truarc engineers are always ready to assist you with your special production problems. Write: Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, New York. 9.13

WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS . . . THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS
WALDES KOHINOOR, INC.

(Advertisement)

R B&W FASTENER BRIEFS

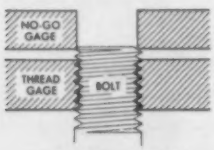
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

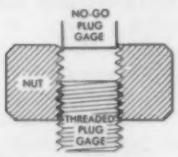
Proper inspection for screw threads

Thread inspection should answer two questions. (1) Will the threads allow easy *assembly?* (2) Is there sufficient thread depth for strength?



EXTERNAL THREADS

Strength requires sufficient thread flank engagement, which is checked by a *minimum* major diameter *plain* ring "no go" gage. Assembly is controlled by thread lead and maximum metal, which are checked by a *threaded* ring "go" gage.

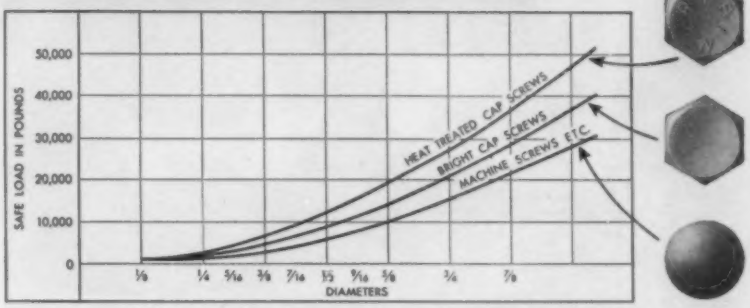


INTERNAL THREADS

The same reasoning holds true here. Use a threaded plug "go" gage to determine any interferences from thread lead or thread diameter that hinder ease of assembly. The unthreaded "no go" plug will assure proper thread depth for sufficient flank engagement.

Checking both thread lead and pitch diameter with two threaded "go" and "no go" gages not only increases inspection cost but also permits acceptance of pieces with insufficient thread metal.

How to simplify selection of fastener material



Safe loads for fasteners made from the three most common steel grades are shown on these curves. Curve for Grade 2 is smooth through the ⅞" size. There is no drop in proof load because RB&W fasteners up to 6" long are cold headed even in 1" diameters.

Basic job of a mechanical fastener is *physical.* It's designed to exert a clamping force.

Fasteners from a *standard* analysis of steel satisfy a majority of the usual requirements for this function. Most times, then, specifications should concern themselves solely with *physicals* for the job. Asking for certain chemical analyses to get the right physicals is doing it the hard way. It can create a needless cost penalty besides.

WIDE RANGE OF LOADS

Generally, the desired physicals can be delivered by a combination of cold working and heat treatment of one of the following common grades.

Grade 1 (or SAE 1010) steel goes into fasteners that offer a design load of 30,000 psi, such as carriage bolts and machine screws.

Grade 2 (or SAE 1018, 1020, 1021) steel goes into bright hex screws and similar items with a recommended design load of 40,000 psi in sizes up to ¾". SAE proof load then drops from 17,350 lbs. in ¾" size to 12,900 lbs. in ⅞" size *unless cold heading is specified!* This is because larger fasteners are often hot headed, resulting in some annealing. The strengthening effect of cold working is lost.

Grade 5 (SAE 1038) steel provides high strength heat treated bolts and hex screws with 60,000 to 80,000 psi design load range.

USE THE FULL INHERENT STRENGTH

When calculated load on a fastener is below those values, you're wasting its strength and cost. Using the smallest size fastener consistent with the load, and tightening to its maximum load actually increases joint strength.

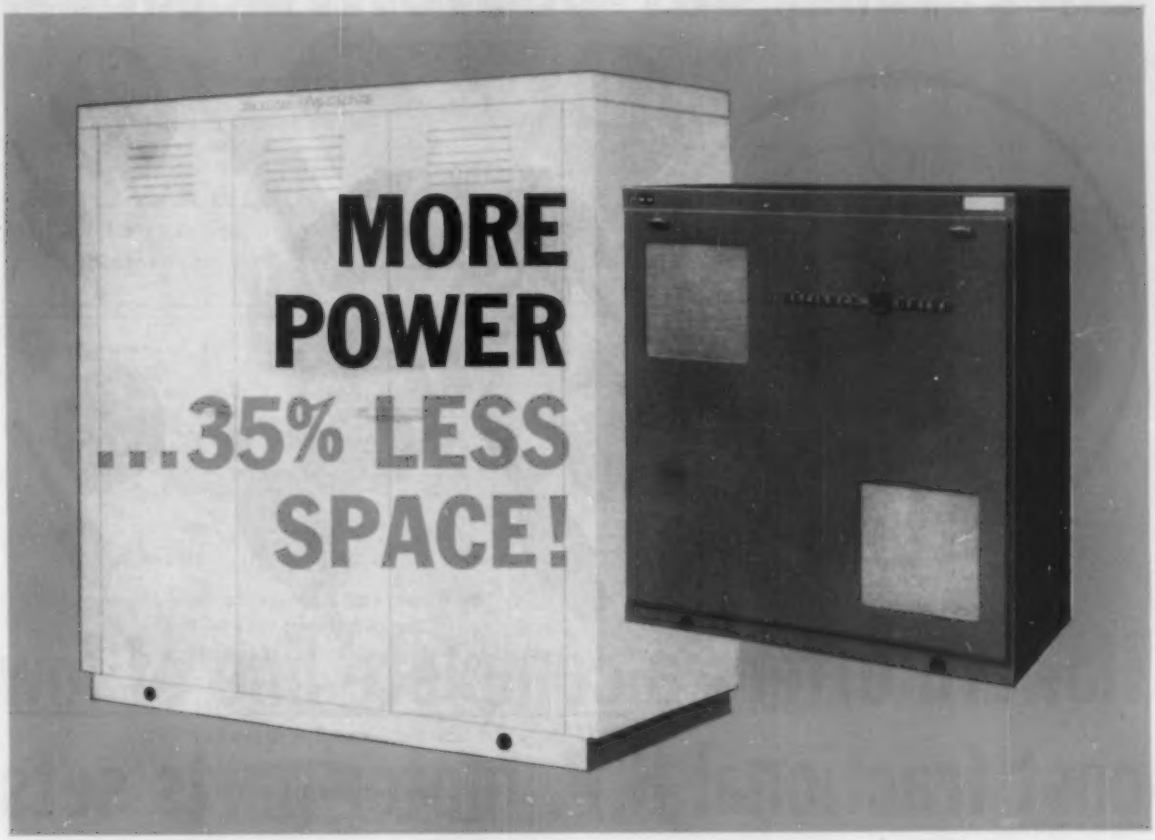
When you need an alloy steel because of space or weight or higher temperature or strength requirements, specifying physicals will automatically force your supplier to go to high alloy steel.

You will get what you need without selecting the exact alloy to be used. Just be sure you're served by a technically qualified and experienced fastener manufacturer.

Bulletin DC-2 gives other helpful hints. Send for it—or the RB&W Man. Russell, Burdsall, & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

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Canadian Division: Toronto, Ontario
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SAVE TIME, CUT COSTS... fill out this

POWERED BY HOWARD®

Howard offers a complete line of low cost fractional H.P. motor parts sets

Ratings from 1/200 to 1 H.P.—Keep costs down—check with us if you have an application using individual fractional H.P. motor parts. Howard stock sets fit thousands of varied requirements . . . include armatures and fields, brushes and brushholders, rotors, stators and fans . . . power your products and appliances with *proven superior quality*. Our large selection of standard models and new semi-automated production facilities let us offer lowest prices in the field. Shown here are just a few of the parts sets in the Howard line. Fill out the convenient data sheet for further details and prices on the parts sets that meet *your* needs!

SPECIFICATIONS

ARMATURES					COMMUTATORS		
Parts Set No.	No. of Slots	Outside Diameter	Inside Diameter	Core Sizes Available	No. of Bars	Insulation	Hubs
11A	11	1.375	⅛ 5/16	¾, 15/16, 1, 1¼	11 or 22	paper, mica, bakelite, or nylon	molded or steel
150	12	1.379	⅛	¾, 1, 1¼, 1½	24	paper, mica, bakelite, or nylon	bakelite or steel
200	8	.960	¼	¾, ⅞, 1 5/32, 1	16	paper or mica	steel
500	12	1.506	.359	¾, 1, 1¼, 1½	24	paper or mica	steel
700	14	1.812	⅛ ½	1¼, 1½, 1¾, 2	28	paper	steel
900	13	1.600	⅛	1¼	26	paper or mica	steel
2700	7	1.380	¼	1, 1¼ 1½	7 or 14	paper or mica	steel or bakelite

ALL MODELS:

SHAFTS:
Shafts are ground from centers for concentricity. Special flats, worms, etc., can be cut on shafts if required. C.R. Steel is normally used, however stress-proof or various types of stainless steels can be furnished if desired.

INSULATION:
Armatures have a fiber end insulator at both ends of the steel laminations. The inside of the slot is insulated with varnished cambric. The armature is wound with heavy formvar copper wire.

LAMINATIONS:
Laminations are stamped in sets from 24 or 26 gauge improved electrical sheet steel. They are riveted together under pressure in an expanding die. The outside diameter of the field can be ground to customer's specifications. Field coils are wound with heavy formvar copper wire, taped with cotton rayon tape, inserted in field core, then double dipped and baked in an insulating varnish. Field leads can be cut to desired length.

MISCELLANEOUS:
Brush holders and caps with correct brush assemblies can be supplied upon request. Special length cores can be made if required. Armatures can be either statically or dynamically balanced, or both, if required.

spec sheet and send for samples and prices

HOWARD
ENGINEERING DATA SHEET
FOR MOTOR PARTS SETS

Fill in this form as completely as you are able with available information and send it to Howard Industries. This will enable us to quickly provide you with samples and prices for the specific job you have in mind. If you would like general information on Howard Motor Parts Sets or other motors in the Howard line, your inquiry will receive prompt attention.

Company _____

Address _____

City _____ **Zone** ____ **State** _____

By _____ **Title** _____

1. Describe general operation: _____

_____

2. Power Supply: _____ **Volts** _____ **Phase** _____ **Cycles** _____

3. Running load requirements and conditions:

- **A. Full-load running speed** _____ **RPM**
- **B. Direction of rotation looking at shaft: Clockwise** _____ **Counter-clockwise** _____
- **C. Continuous Load** _____ **H.P. or** _____ **Oz. In. Torque**
- **D. Intermittent Load** _____ **H.P. or** _____ **Oz. In. Torque**
  1. **Length of time at full load** _____ **Min.**
  2. **Idle running** _____ **min; Time at rest** _____ **min.**
  3. **Maximum momentary torque** _____ **oz. in.**
  4. **Number times per hour load capacity is repeated** _____

4. Space available:

- **A. Maximum diameter** _____
- **B. Maximum length** _____
- **C. Set dimensions to be interchangeable with competitors** _____

5. Bearing and Journals:

Ball bearing _____ **Sleeve Bearing** _____

6. Shaft Extension:

- **A. Single** _____ **Both ends** _____
- **B. Diameter** _____
- **C. Length** _____
- **D. Describe special shaft features:** _____

_____

CUT OR TEAR OUT COMPLETED FORM AND MAIL IMMEDIATELY!

Other Howard Motors: UNIVERSAL & D.C. 1/200 to 1 h.p. / INDUCTION 1/1400 TO 1/4 h.p. SHADED POLE 1/2000 to 1/8 h.p. / SERVO MOTORS / GEAR MOTORS / BLOWERS

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New York area: 157 Broad St., Redbank, N.J., SH 1-3356

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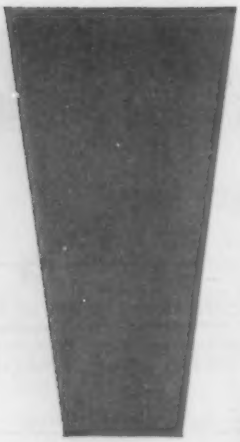

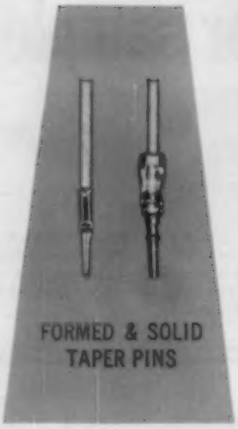

FOR A TIGHT FIT IN A TIGHT SPOT...

If miniaturization has put your circuits in a tight spot, you can build reliability right into them with the AMP Taper Technique . . . formed taper pins or new solid, pre-insulated taper pins . . . two-piece or molded one-piece stackable blocks . . . plus a wide assortment of taper receptacles.

The AMP Taper Technique offers the most complete line of taper products available plus many extra features. A three-and-a-half degree taper assures the firmest fit of pin in block. A-MP Pull-Test Insertion Tools assure the proper seating of pins. Hand and Automachine crimping tools assure uniformity of pin attachment to your circuit leads.

And—with the addition to the AMP Taper Technique of the new Solid Pre-Insulated Diamond Grip Taper Pin and the new one-piece warp-free block, you can have the greatest flexibility of product choice for your circuit design and manufacturing operations.

You can concentrate more circuits in a smaller space—and be sure of reliability when you use the AMP Taper Technique. Send for our new catalog today.

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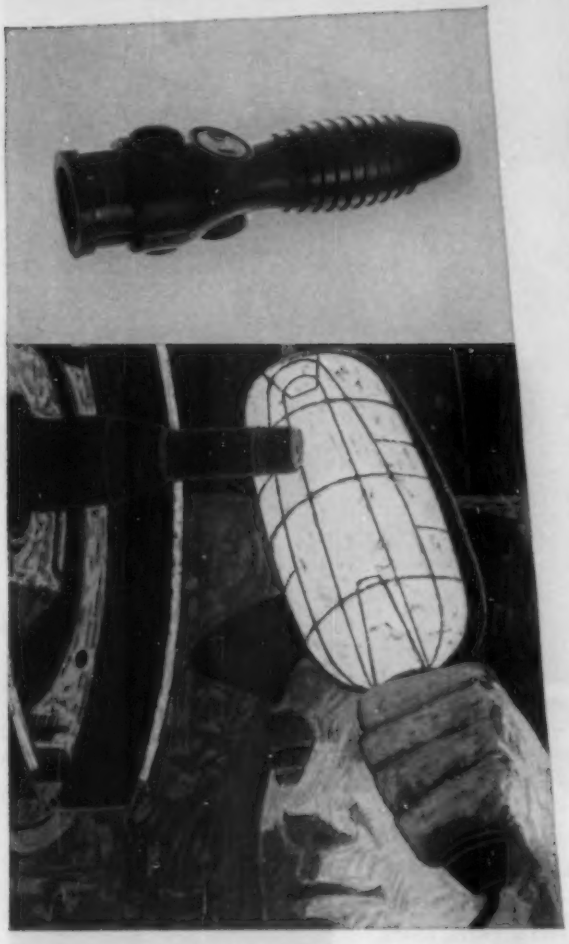

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Need a practiced hand for solving production problems? Your Firestone Technical Service Man is a specialist at handling unique manufacturing demands from oil-resistant trouble-light grips to precision fire extinguisher gaskets that acids can't eat. Each takes a special compound; each meets a special need. And whenever you ask him, he'll meet *your* special needs with a custom-tailored plan. He'll analyze your specifications expertly and make precise recommendations. Then he'll put Firestone's complete rubber and latex custom-production service at *your* service.

Firestone's extensive laboratory facilities develop the exact compounds and product designs to fit your requirements. And Firestone's mass-production facilities deliver close-tolerance, high-volume output at reasonable costs.

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Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

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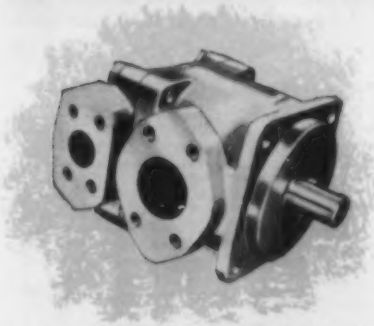
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

VANE PUMP POWER for CASE®

2000 PSI...BY DENISON



2000 PSI HYDRAULIC PUMP
. . . is incorporated into power systems of dozens of types of earthmoving equipment by leading manufacturers. Denison 2000 psi hydraulic power gets jobs done faster with dependable trouble-free operation for toughest workloads.

DESIGNERS ENGINEERS . . .
Write for your copy of Bulletin P-9-3 on Denison "T1D" Series Vane Pumps. Includes complete specifications and operating data.

These completely new Case tractor shovels—the W-10 and W-12 TERRALOAD'R®—deliver outstanding work capacity. They're products of the J. I. Case Co., Racine.

And ultra-efficient Denison hydraulic power is helping these high-speed Case units do excavating, loading, grading, hauling and materials-handling jobs faster . . . at *lower operating cost.*

The W-10 (2 cu. yd.) and W-12 (2½ cu. yd.) TERRALOAD'R® dump-buckets get high efficiency, low-cost power from a single Denison 2000 psi vane pump.

Key advantage – high volumetric efficiency is *continuous* in Denison pumps . . . no drop-off in work speed – no sluggish operation to slow up the job.

Plus these advantages –"cartridge" construction of Denison pumps means speedy in-field servicing. All-weather starting features prevents pump damage. Denison pumps guarantee less weight, less cost-per-horsepower . . . more payload per dollar in your earthmoving equipment.

Your Denison Hydraulic Specialist can tell you more about significantly improving equipment performance with *hydraulic power to 5000 psi.* Call him in to discuss *making your equipment more profitable to the man who buys it!*

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CIRCLE 51 ON READER SERVICE CARD 51

(Advertisement)

Secrets of Successful Seal Design

Fundamentals — No. 1 of A Series

SPACE — Around Sealol the bane of our existence is the job which comes to us designed in toto — "no changes allowed. Please fit your mechanical seal into this space". If there isn't space enough, the solution will usually be a compromise with performance standards sacrificed. As an example, a 1" diameter shaft will require a standard Sealol seal with a .531" operating range and a mating ring preferably .250" for a total of .781". This particular seal allows .020" for tolerance stack-up and shaft end motion. But suppose you have allowed us only .700" with a stack-up tolerance of .040"? We may be able to reduce the space required for the seal without sacrificing performance but only if the stack-up tolerance can be reduced to .020". In some cases selective assembly or shimming can produce satisfactory operating life with a bare minimum of axial space. ***Moral*** *— Send us your design before it is frozen.*

P.S. Diametrical space requirements do not bother us, but we do urge you to take into account the relative co-efficient of expansion of the stainless steel cup of our seal and the material into which you want it assembled. Sealol's Bulletin #7, Page 6, has some charts which may be helpful.

CHARACTERISTICS — In the old days, say ten years ago, you could spot an industrial seal application as distinguished from an aircraft high-performance type of application, a mile away. The former provided for rotation of the axial movable part — the latter invariably provided for these axial movable parts to be stationary in respect to the shaft. Times have changed, but designers generally favor the stationary seal where overall axial space is at a premium since it requires only 40 to 70 percent of the space of a rotary seal. Naturally, they are also much lighter. Furthermore, when shafts start turning at speeds beyond 5000 RPM, springs, pins and assorted hardware have a way of losing their functional abilities and for these situations, the stationary seal is mandatory. On the other hand, rotating seals are usually more rugged in their construction, and they are self-cleaning. They are used extensively on industrial pumps, blowers and compressors. We don't propose to be too dogmatic about the small table shown below, but it serves to delineate our present parameters for stationary and rotating seals.

MAXIMUM OPERATING CONDITIONS

	Stationary Seal	Rotating Seal
Shaft Speed	100,000 RPM — ¼" Dia.	5,000 RPM to 3" Dia.
Temp.	—425° to + 1000°F	—60° to +450°F
Pressure	2,000 psi	1,200 psi

Note: Maximum conditions indicated do not mean that all are available in a single seal.

Viton-A and Teflon are registered trademarks of the E. I. duPont de Nemours & Co., Inc.

PRESSURE — One of the most critical conditions, but one of the most inconsistent, is pressure. Many the time there has been much Sealol head-scratching over a 2 lb. pressure differential in one test rig, whereas pressures in excess of 2000 lbs. were being handled in routine fashion in an adjoining rig. We would be delighted to exchange data with you on pressure phenomena, but in the meantime, you may be interested in the following tidbits. Since operating life of a seal is a function of face load, pressure considerations can be really critical. We design to a unit face-load usually of 8 to 40 psi. depending, of course, on the spring and area involved. Hydraulic pressure of the fluid being sealed and the fluid film pressure across the seal face must also be reckoned with. Around our premises, our engineers banter back and forth a semantic generality called 'seal balance'. If you are interested, ask us for NCIH Paper "Factors in Designing for Mechanical Seal Applications to Hydraulic Equipment". Seal size has a considerable bearing on pressure capability, and as shaft diameters go up into sizes, say above 12 inches and pressures go to 500 psi, seal ring sections become quite massive to prevent distortion. Incidentally, 100 psi is about the maximum pressure we recommend for an unbalanced seal. For higher pressures, we must reckon with interface film destruction resulting from non-balanced face loads.

SHAFT SPEED — Top-flight designers are certainly stretching seal performance in many ways. Not the least is your incredible ability to cram into minute space great horsepower performance. This is meaningful to us, because the shaft speeds you now call for are exceeding, in many instances, speeds of 50,000 RPM. Of course, a 100,000 RPM — ½" shaft is probably within the capability of existing seals, but from a seal standpoint, the relative surface speed of the seal faces should not exceed about 18,000 FPM under ideal conditions. Irrespective of face materials, this seems about maximum for full contact and leakproof sealing today.

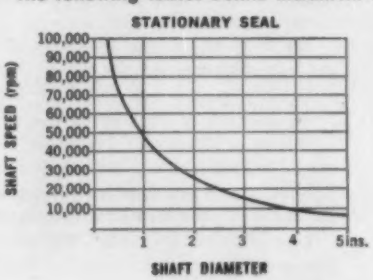
TEMPERATURE — As seal designers, our temperature goes up when you ask us for high performance beyond 450°F. ambient. This is about the usable limit for today's elastomers, such as Viton-A and Teflon. However, this too may be misleading. There are Sealol-Flexibox elastomeric packed seals doing a beautiful job in oil refineries with pump temperatures of 750°F. The secret here is, of course, controlled temperature at the seal to produce seal ambients below 450°F. However, within the last two years, Sealol's welded bellows seals are performing well at temperatures to 1000°F. Our thought for the day — if it can't be cooled to within elastomeric limits — consider the all metal welded bellows seal.

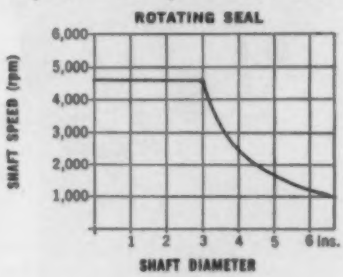
MOUNTING ARRANGEMENT — If possible, the fluid being sealed should be on the O.D. of the sealing faces. Centrifugal force of any fluid between the faces will then work in your favor to prevent seepage between the rubbing faces. Seals can function satisfactorily with fluid on the inside of the seal faces. We can both avoid long hours on the assembly line later looking for leaks if we arrange matters so that the fluid is on the outside of the face.

RUN OUT — We've heard many definitions of run out, but here is ours: The deviation of the plane of the rotating ring from a plane perpendicular to the axis of the shaft. It usually results from a lack of squareness of the rotating sealing surface to the axis of rotation. It causes a wobble of the ring and tends to bounce the seal ring away from contact at high rubbing speeds. For a 2" shaft at 20,000 RPM, run out should not exceed .0005" at the point of contact.

If these thoughts have aroused your interest, write to us with your questions, and we will be glad to elaborate.

The following tables define maximum shaft speeds under optimum conditions.





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Faultless Casters

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FOUNDRIES—Core Trucks
GARAGES—Dollies
HOSIERY MILLS—Stock Trucks—Yarn Trucks
HOSPITALS & HOTELS—Linen Trucks
INDUSTRIAL PLANTS—Assembly Lines
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Load Capacities in a New Dimension

NOELTING **Faultless** Casters

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1. **CORRUGATED TOP PLATE** . . . fully hardened to give added strength. Slotted mounting hole spacing permits easy attachment to new equipment. Fits holes drilled from centers of 2⅝" x 3¼" to 3" x 3" when used as replacement casters.
2. **MAIN LOAD BEARING** . . . consists of 21 hardened, polished balls (¾" dia.) rolling in large dia. hardened, lubricated raceway permanently attached to caster horn to assure perfect alignment.
3. **LOWER THRUST BEARING** . . . contains 10 hardened steel balls (⅝" dia.). Hardened raceway is machined from bar stock. Ball retainer is hardened formed steel.
4. **EXTRA-LARGE DIAMETER KINGPIN** . . . assures bonus strength in this caster, and strong, trouble-free construction.
5. **CLOSE FITTING, FORMED STEEL CUP** . . . protects thrust bearing from dirt, water and other foreign matter. Holds lubricants in bearings, keeps floor clean.
6. **HEAVY GAUGE, FORMED STEEL HORN** . . . easily absorbs highest rated loads and thrust. Correct offset permits easy swiveling and shimmy-free running.
7. **FULL SELECTION OF WHEELS** . . . for all types of floors and operating conditions. Bolt and nut axles permit quick wheel replacement when needed.

SERIES L9700 RIGID PLATE CASTER
Wheel types and sizes, load capacities and overall heights to match L900 Swivel Plate Caster.

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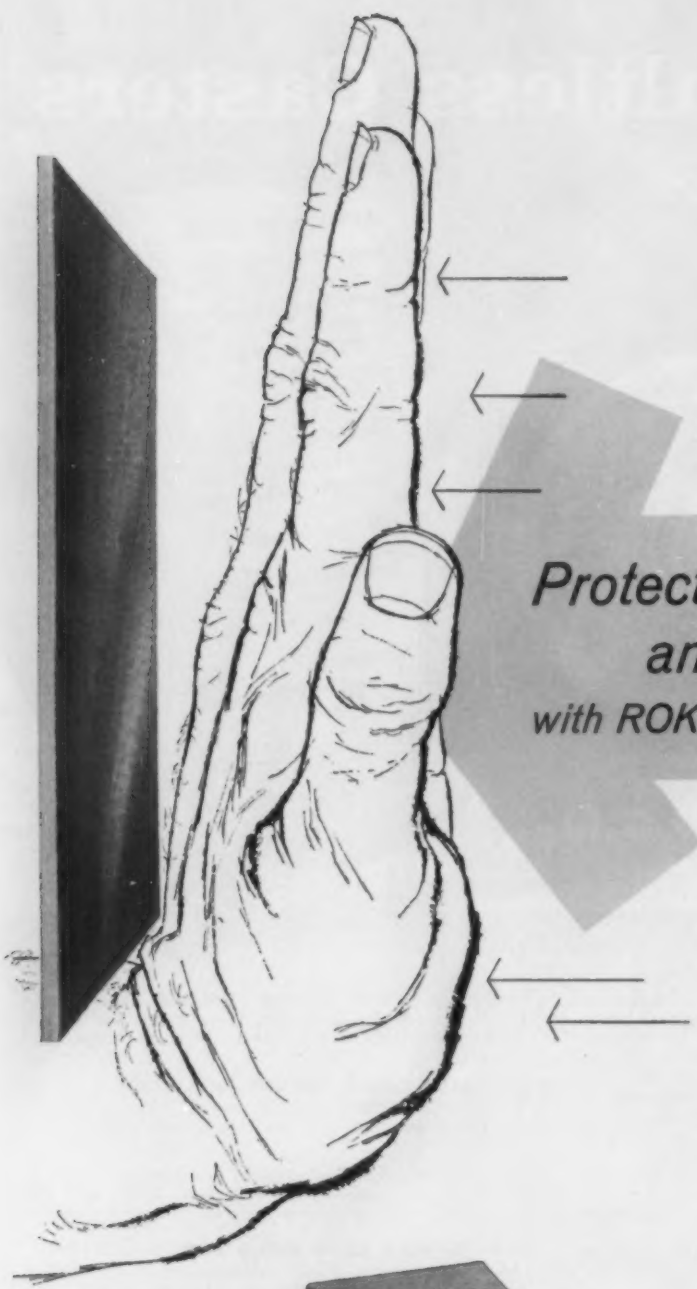
CIRCLE 53 ON READER SERVICE CARD 53



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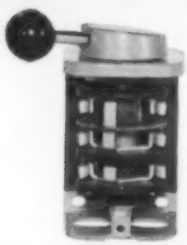

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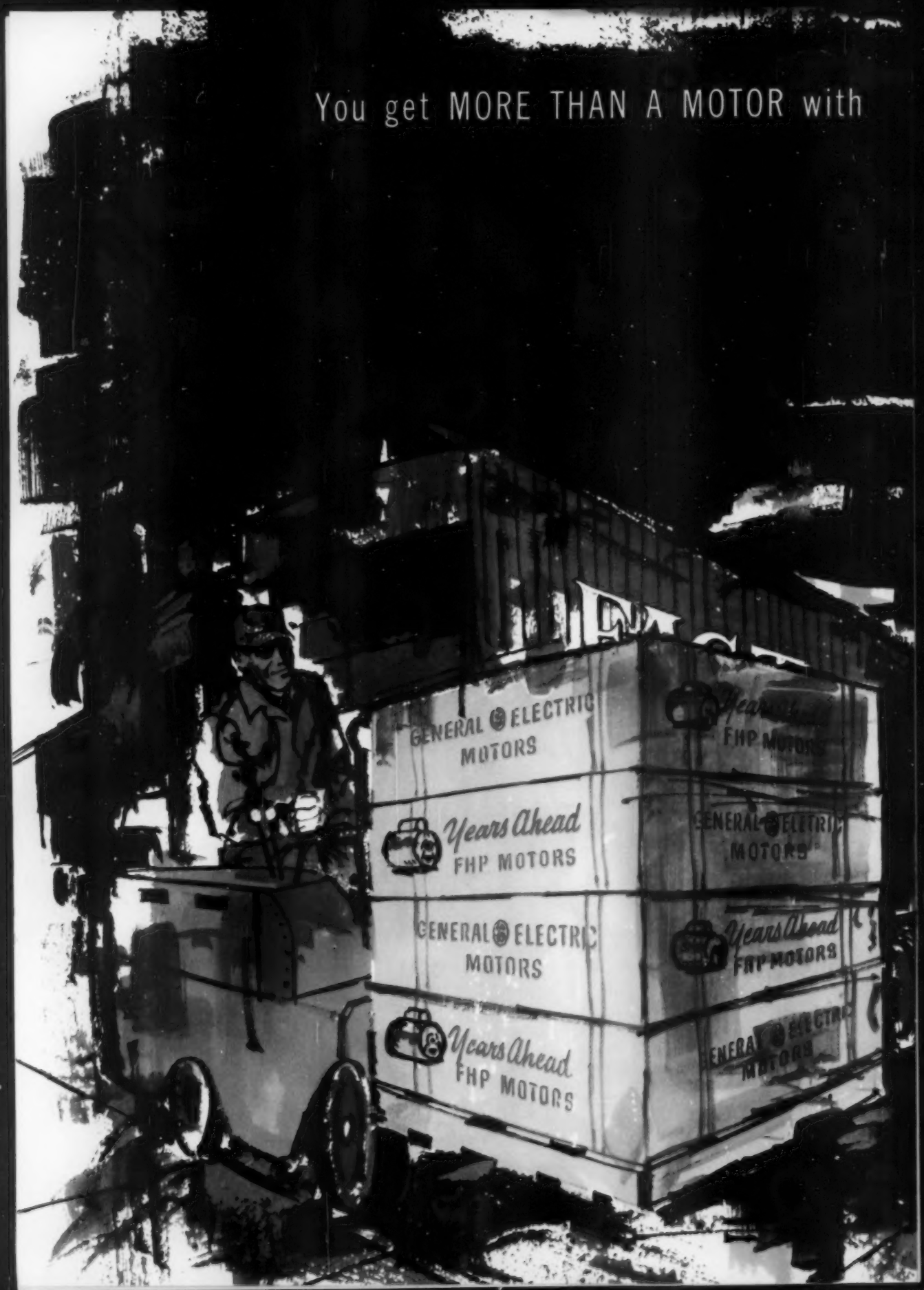
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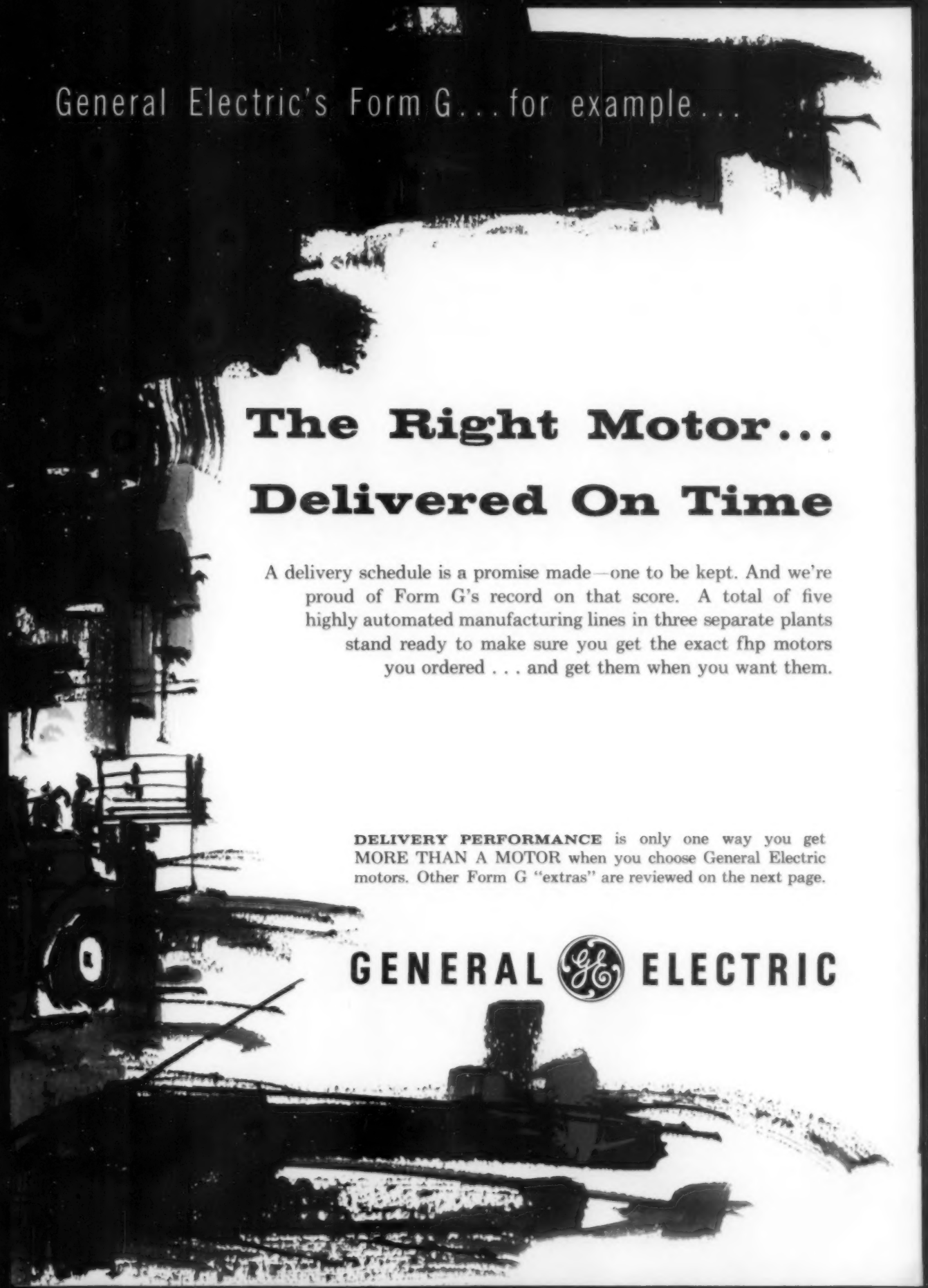

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(Advertisement)

NO. 4 OF A SERIES

"How to Design Welded Aluminum Structures"

Composite Stress-Strain Curve Provides More Realistic Design of Welded Aluminum in Compression

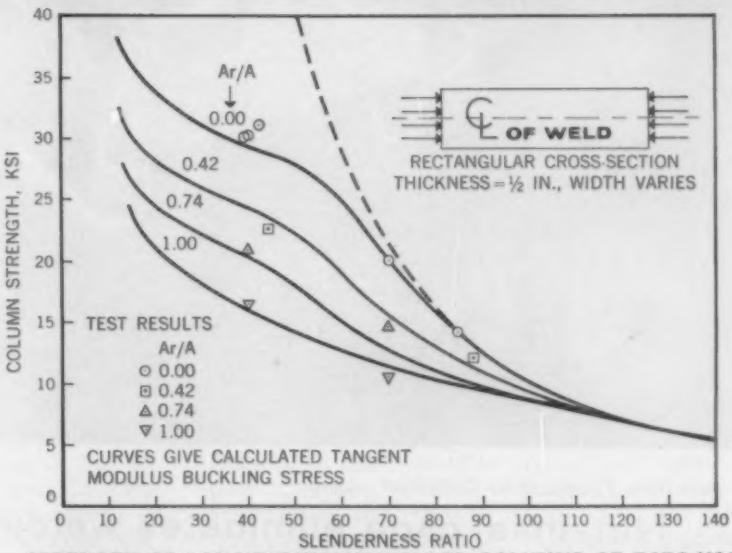
Mr. Harry N. Hill, *Engineering Design Division Chief, Alcoa Research Laboratories, Aluminum Company of America, reports research findings presented at the 1959 annual meeting*

In determining the strength of welded compression members, the design concepts discussed in earlier Alcoa articles on "reduced-strength zone" and "10-in. gage length yield strength" are used. Just as with tension members, the strength of a welded compression member depends on the location and extent of the welds.

Strength of columns or compression members at stresses above the proportional limit of the material is greatly influenced by the shape of the stress-strain curve. Tests at the Alcoa Research Laboratories years ago demonstrated that use of the "tangent modulus" in the column strength formula gives calculated strengths that agree closely with actual test results. The tangent modulus method for calculating column strengths is now quite widely accepted.

The strength of a column with several pieces joined by longitudinal welds is controlled by the dimensions of the member and the stress-strain relation for the complete cross section. The stress-strain relation can be constructed as a composite curve of the heat-affected material in the reduced-strength zone and the material in the remainder of the cross section. Strength of the column can then be computed by the tangent modulus method, using this composite stress-strain curve. A family of column strength curves with different values of A_r/A, similar to those shown in the accompanying chart, are useful in designing.

The chart shows the reliability of this method of calculation when applied to column specimens composed of two pieces of ½-in.-thick 5456-H321 plate joined by a longitudinal butt weld. Several widths of plate were used to give different ratios of reduced-strength area (A_r) to total cross-sectional area (A).



STRENGTH OF LONGITUDINALLY WELDED COLUMNS OF 5456-H321

Use of the composite stress-strain curve and the tangent modulus method indicates that most welded aluminum members under compression are *not* limited by the properties of the material in and adjacent to the weld. In fact, specimens with over 40 per cent of the cross section in the reduced-strength zone developed strengths more than *50 per cent greater* than those representative of the material adjacent to the weld ($A_r/A = 1.00$).

Strength of a column with transverse or other localized welds *can* be calculated with principles applicable to columns of varying cross section. However, the method is too laborious for most ordinary design procedures. Simplified techniques suitable for design are described in the ASCE paper *Designing Welded Aluminum Structures.*

Welds confined to the end of a pin-ended column have negligible effect on the strength of the member except to limit the maximum stress for a very short column to the 10-in. gage length yield strength of the welded region. Even columns with transverse welds at mid-length have surprisingly high strengths, if the length of the reduced-strength region is small compared to the column length.

Future articles in this series of design concepts will feature strength of welded beams, fillet welds and design data.

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PRODUCT ENGINEERING HORIZONS

March 28, 1960

Managerial Momism

Americans were shocked, after the Korean War, to discover how many of our soldiers, when captured, yielded to brainwashing. Some turned informer, some defected, some lost their will to live. Communist application of psychological techniques was unbelievably successful, suggesting that the technique could be applied to control (not just dominate) our world, given time.

The military are attempting to develop countermeasures to this problem, whose roots lie in our national culture. According to psychologists, these are the three main ones:

1. No strong faith, traditions, or other morale factor.
2. Confusion, lack of sense of purpose, no real goal.
3. Selfish and materialistic outlook on life.

The Chinese communists weren't tough on the majority of prisoners; they were, in fact, just the opposite. They welcomed POW's with, "We realize you are victims of your leaders, not our enemies," fed them as well as their own men. POW's were "educated" to believe their best interests were served by being inconspicuous members of the group—by becoming a formless, leaderless, purposeless mass. They were encouraged to report any member of the group who committed any infraction of the rules, even praised in public for doing so. The member reported was not punished, but talked to like a young, backward child until he confessed his act publicly, explained why, and asked forgiveness. Through all this, the key step was to separate the leaders. If a group showed signs of looking toward one individual as a leader, he was removed. The prisoners were encouraged to lose hope, to reject individuality and independence.

The result? Some 7000 Americans were held in a camp so lightly guarded that—under morale and conditions of World War II—they'd have lined up to escape. Instead, "brainwashed" prisoners went to the opposite extreme—thousands crept off to their cots, lay down, and died of a disease that doctors could diagnose only as "Give-up-itis."

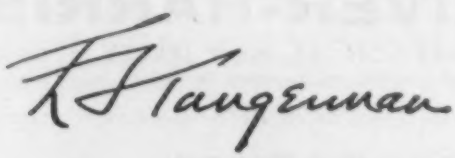
To achieve all this, the Chinese eliminated from the group only about 10%. Who? Officers, NCO's, and *all* others who refused to discard their individuality.

Brainwashing was a complete failure on a group of 243 Turks who were held prisoner under the same conditions, subjected to the same treatment. As long as these men were held in a group, they unquestioningly accepted the leadership of the senior member. When the Reds found themselves dealing with groups of one man each, they gave up. 243 Turks went in and 243 came out.

Despite this lesson, we apply pressures on the armed services to reduce discipline almost to the vanishing point —to conform, in fact, to the "understanding" procedures by which we are rearing our children and even operating our economy. We've undertaken an expansion of what Philip Wylie called "Momism"—the maternal over-indulgence of growing children's whims and "personalities." Misguided by misinterpreted psychology, we have abdicated parental responsibilities. The result is a generation of apron-stringed brats who resist, defy or are literally unable to recognize authority, who can't differentiate between respect and subservience. We teach leadership, but not followership. "Boss" has become a dirty word, criticism an end in itself. We have the "Beats," whose Dynamic Negativism is an ideal atmosphere for brainwashing.

In industry, there is a strong trend in the same suicidal direction. We've been "decentralizing" industry, but mostly without untying the financial apron strings at the same time. Middle management has responsibility without final authority, engineers are expected to design within parameters so limited that they become perimeters—and subject to committee control. Often the committee is so remote that it functions merely as a financial brake—a penny protector. Thus the primary criterion of a design is not whether it is good, but whether it is cheap. Engineers get lip service, "understanding," are encouraged to confess their "sins" of working to such criteria as quality, to report those of their number who forget money.

Is it so strange, then, that we find "Give-up-itis" all along the line?



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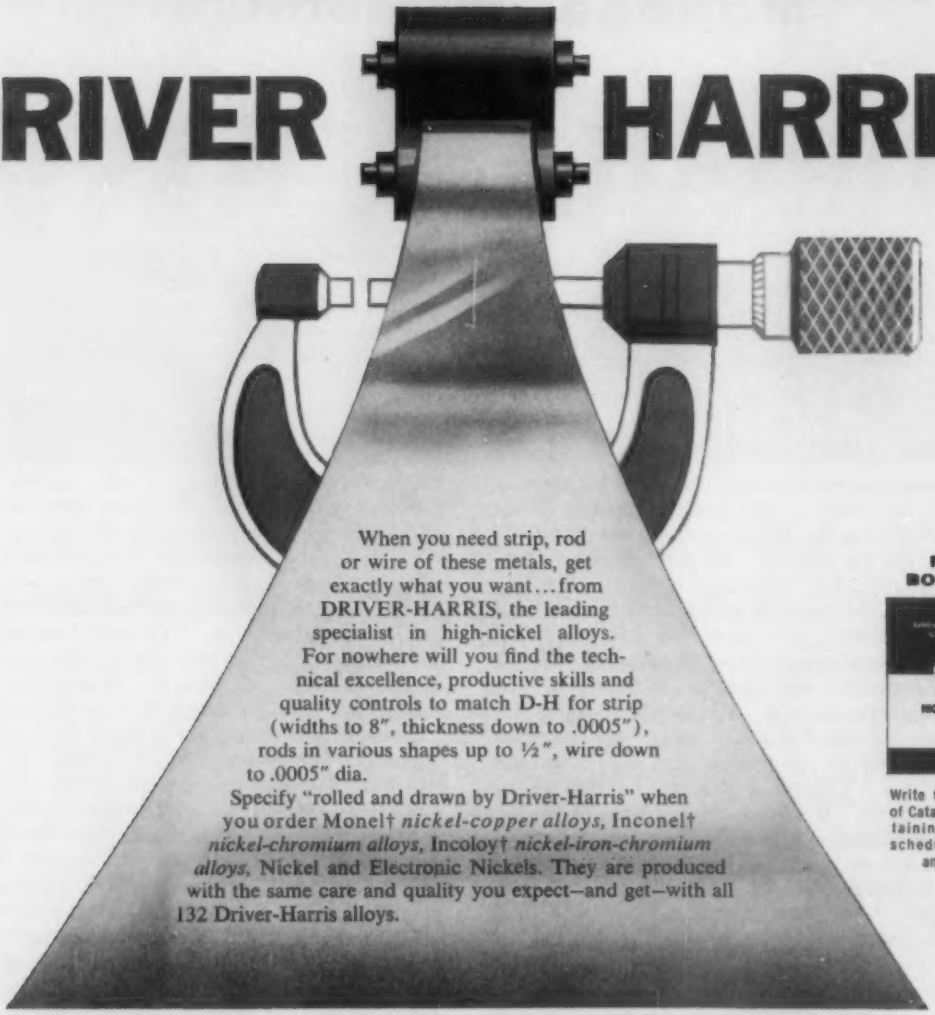

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ARE WE CONTENT WITH A "CRACKTHROUGH"?

Last week's Horizons made a sharp attack on the high-level conferences that cry about the lack of scientific breakthroughs, and wondered if education and industry were any more to blame than our entire "maximum security" way of life. Feeling that this is a broad and basic controversy in which engineers are involved, both professionally and as citizens, Editor Tangerman decided to give industry and education a chance to have their say. McGraw-Hill correspondents interviewed research directors and engineering deans in various states, including Hawaii, and in Canada. You'll agree with some, disagree withe others, but you won't be bored.

New academic methods needed

DR GORDON S BROWN,
Dean of the School of Engineering
Massachusetts Institute of Technology
Interview by PAUL GIGUERE, Boston

Far-reaching changes in attitudes and methods are needed to encourage greater creative research effort. With support from a grant of $9,275,000 from the Ford Foundation, we have been making some revolutionary changes in curriculum and methods in the education of electrical engineers.

The basic academic problem is how to give human beings, when they are young, an interest in the whole learning process so that they get the spirit of being bold and thinking out new things. Changes contemplated or already adopted in our methods of education at MIT include new textbooks and new instructional laboratory equipment, and an intensive effort to educate teachers as well as their students on the needs of the future.

For better engineers we must broaden and deepen the instruction in science; stimulate creative laboratory activity; subordinate vocational aspects of training until a strong foundation is built; recognize that students, like all people, are not alike in their interests and talents, and that seniors should study a wide variety of topics.

Educators have traditionally believed that their task was to train students to think; it is just as important to teach students what they should think about. Engineers must not only learn the How of the technology of say, the next 25 years, but they must also keep up with the Why. A broad foundation is imperative because so many areas of engineering now overlap.

Academic policies need change as well. This will be much more expensive and time-taking than rewriting textbooks or building teaching laboratories that show concepts instead of gadgets.

One other deterrent is the immature attitude of engineering undergraduates. Freshmen who bring their toys with them —radios and hi-fi sets—must be prepared to give them up and study physics, math and lots of theory.

Give researchers more freedom

DR ATHELSTAN F SPILHAUS,
Dean of the University
Minnesota Institute of Technology
Interview by E H SEIDL, St. Paul

Give researchers less direction and fewer predetermined goals and you will give them the inspiration and encouragement needed to achieve breakthroughs. Over-direction of research stultifies; that's why we have no research director at the university.

We have no salesmen getting support for our researchers. If a research man feels that a particular type of project qualifies for government support, he makes the arrangements himself. Education and research must be woven together, so I am firmly against an organization with a separate research foundation.

Teaching creativity must come by example. Teachers must bubble over with excitement—serve as examples and inspiration, not as stern directors. The traditional European school and its "Herr Professor" should not be the American way.

In supporting researchers, seek excellent people and back the person, rather than a predestined project. Too often the attitude is to predetermine whether a project will "pay off"—evaluate it on the early application of the idea rather than on its possible future benefits.

I take a dim view of the stultifying plethora of conferences on science and

technology. And some of the societies have grown so big that most of their members are talking only to themselves, when the need is for crossfertilization of ideas.

We mix life sciences with physical sciences. We made a mathematician head of chemical engineering. Power and mechanical engineers are no longer interested in steam, so you need chemists in mechanical engineering to work on combustion and propulsion.

Insatiable curiosity is the key

JOHN M CAMPBELL
Scientific Director
General Motors Research Laboratories
Interview by WES PERRY, Detroit

I endorse the conclusions of the Worcester Conference of the need to encourage "conditions favorable to achieving bold, imaginative pioneering in basic research and in technological innovation." But there never was a time in our history when science and technology have had greater support than they have today.

In discussing this subject we must distinguish between science and technology. Our society is ready and eager to develop the technologies that follow scientific discoveries as never before. The real problem is to find and to encourage men who are capable of making original scientific discoveries.

The men who make discoveries must be gifted with an insatiable curiosity and at the same time endowed with fortitude to undertake the disciplines required of the pioneer. Once we find such men we can support them with the tools they will need and with the rewards of society.

The General Motors Corp, for example, has created a great technical center as a place for such people to work. But the buildings and the facilities do not make scientific discoveries. These must take place in the minds of creative people.

Federal aid is the answer

DR J RUSSELL BRIGHT,
Associate Dean, College of Liberal Arts
Wayne State University, Detroit
Interview by WES PERRY, Detroit

I would not disagree one bit with those "29 carefully chosen, noncombative words" in the report. The editorial is interesting but is perhaps somewhat misleading regarding several important points. I will be specific.

The editorial infers that we have had "crackthroughs" but no "breakthroughs" or long leaps ahead. What about basic research since 1939 in biology, chemistry, mathematics and physics plus miracle drugs, television, solar energy, atomic power, thermonuclear devices, space astronautics and uses of radioisotopes? These do not seem like small fissures to me.

Mere recognition of conservatism as the cause of a slowdown should suggest the answers. But let us not confuse conservatism with tradition and reputation. Research is neither liberal nor conservative. He who wallows in tradition will do little or no research.

Research is an industry and deserves recognition as such. Much of the basic research is done at the universities, as it should be, and most of these research programs are of more than one year duration. For sponsored projects, there are too many status reports, technical reports, annual reports, financial reports, etc., but most investigators would dispense with all of them if they could.

Academic freedom and the campus atmosphere are conducive to the pursuit of bold and imaginative research investigations. Students and young researchers can be encouraged to strike out in new directions, if able and qualified colleagues are around and if funds, space and equipment are forthcoming.

Engineering and scientific societies can do something about this—see that more funds are allocated to education and research. We did something about it in Michigan: in August 1959, we established an Institute of Science and Technology at the University of Michigan with $500,000 appropriated by the legislature for the first year's operation. Present indications are encouraging.

The present increase in the gross national product, about 3% a year, is too low, especially when compared with certain foreign countries. The remedy can come only in increased support for our universities, and direct federal aid for buildings and faculty salaries is one way. (Conservative engineers will not like this.)

We have been making breakthroughs all along. My recommendations would include:

1. Liberal research policies for both sponsored and unsponsored research.

2. Recognition of research as an industry.

3. Encouragement of both basic research and applied research and development.

4. Immediate enactment of direct federal aid for faculty salaries and for construction.

5. Convening of a second parliament of science similar to, but greater in scope than the one held in Washington in 1958.

We need a substitute for the hunger drive

DR LEO YAFFE,
Faculty of Engineering
McGill University, Montreal
Interview by CHARLES GRAHAM, Montreal

I have some reservations about the conclusions of the WPI Conference report. Both "breakthroughs" and "crackthroughs" are important in research, but you don't do research by sitting down and saying, "I am going to break down barriers!" You do research simply to satisfy intellectual curiosity.

The real problem is to rouse intellectual curiosity in the right kinds of young people. Once they have been started they can be trusted to do bold thinking and research into imaginative new areas.

It is not as easy as formerly to arouse the research spirit because the kids just aren't as hungry as they used to be. I blame this more on the home than on any other influence. Parents in general have a much easier time of it today than *their* parents had. They prize material things more; children pick up this attitude and think of landing a good job with high pay, rather than devoting "mental sweat" to advancement of knowledge. We need some substitute for the missing hunger drive.

As for the ability of present professors to teach young engineers and scientists to attempt imaginative research, that is exactly what every professor worth the name is doing. He must stimulate basic thinking by the student or he is not fulfilling his job as a teacher.

The problem of one-year scheduling, mentioned in the editorial, is not a crucial one. I get research grants on a three-year basis, and can schedule a student's program over the entire period of his post-graduate work. Of course, as everywhere, there is a general shortage of funds.

Two things the professional societies can do are: bring outstanding scientist-speakers to students who would not otherwise hear them, and influence government thinking so more research funds will be provided.

Creativity can be smothered

JOSEPH M PETTIT,
Dean of Engineering
Stanford University

Interview by JENNESS KEENE, San Francisco

The basic problem in talking about creative ability in people, is that it's not uniformly distributed throughout the population any more than intelligence is. All we can hope to do is to provide a favorable climate in which gifted people can develop and strike out in bold new directions. While it is possible that creative ability cannot be taught, you certainly can smother it if you aren't careful.

No one is deliberately stifling creativity. But in a university, there are basic limitations with students engaged in basic research. Research to them is a means to an end—a degree. They naturally turn to subjects than can be finished so they can get the degree, and go on to a job. It's not a feeling of insecurity, but simply a need to tackle a project, package it, and then go on to long-range investigations.

Professors may be a limitation in the picture, since they are not all gifted people either. The problem is how to keep good professors on the campus when there are other places to go—especially true in engineering. There are some outstanding campus centers where research is going on, and I like to think we have one. But in the average engineering school across the country, the most gifted and daring people often are not faculty members.

Just give it enough money

WILLIAM W FOX,
Chief Engineer
Convair—San Diego

Interview by PETER KAYE, San Diego

Lack of money is almost the only obstacle to achieving bold, imaginative pioneering in basic research and technological innovation. Progress starts with technological ideas and market analysis and proceeds to a new product—one that will have an edge on competitive products when time and the customer demands it. Consider the supersonic airliner of the future. We can build one now, technically, and are testing wind-tunnel models of a delta-wing plane. But such an airliner will take huge sums of money for development—some might come from a military prototype.

Convair has a student cooperative program with San Diego State College. Young engineers work up to 20 hours weekly, and during the summer we hire 15 to 20 pregrads for the vacation period.

The company is looking for "dedicated, young fireballs with 50 years experience." Failing this, Convair encourages, and gets, eager and intelligent engineers—not just bookworms. Many younger engineers have helped in breakthroughs in aircraft design —no one man designs an airplane.

More prestige will do

DR EBERHARDT RECHTIN,
Telecommunications Division Chief
Jet Propulsion Laboratories, Los Angeles

Interview by JACK MEYER, Los Angeles

I disagree with the philosophy that calls for "big leaps" rather than little steps. Different-size steps can be taken by different people. You can only move so far, so fast. The trouble with making generalizations about research is that every individual has different capabilities in different directions. And today we are advancing so rapidly that some of our minor achievements would have been considered major ones a short time ago. Some major steps of the past are only great in the context of their time.

There's a lot of unglamorous but necessary detail—sometimes the only way to find out an idea will not work is to try it. "Crackthroughs" are essential elements; "breakthroughs" often only are recognition of an orderly pattern created by a series of crackthroughs.

Cost of the successful jump is not necessarily greater than the cost of the successful step. The size of the jump is related more to the amount of risk involved.

In basic research, 10% success is good.

In support research, it's about a 50-50 chance.

In advanced development, 75% of the attempts work.

In product development, you expect 95% success.

But even if small steps have to be taken, we still must create more favorable conditions for the man who is willing to take all this information, put it together, and challenge all the accepted theories. I agree completely with Tangerman's statement that all most of us can do is to stand back and give them room.

There is too little prestige for the professional. Most work for administrators with little or no technical ability, but the man who manages people gets more recognition than the engineer or scientist who only handles "things." The highly qualified (less than 1% of the total population) technical professionals need the authority to make and carry out decisions. Today, the number of people who can say "no" far exceeds the number who can say "yes" and get things moving.

One reason why we don't give more recognition to scientific people is the professional "advisor" who sits on important committees, and with no significant accomplishments of his own, gives advice to people who know even less than he does. When he makes "butches," this decreases the respect the layman has for the scientist.

We must give recognition to those best qualified to do the leaping, if we want to see great technological leaps. In the Olympics, you pick the best, give them the help you can and the equipment they need. Then you stand back and let them leap. Team managers don't go out on the field and try to leap over the hurdles for the sake of popular attention.

The first step is to find and train the "leapers." Educators should be looking for them from about the eleventh grade on. They are not the sickly, psychotics who scream at teachers. They will be superior in most ways to the rest of their high-school graduating classes. Many of them could do almost anything well, and some are really remarkable people.

Then, we must recognize our professional scientists; they are the only ones who can tell us what risks we are taking, and the penalties of failure. If you needed a brain operation, you would go to the best hospital, and the best specialist to learn just what the risks were. And you would have enough confidence in the surgeon to leave the decision to him. You wouldn't rely on a general practitioner or the opinion of the hospital's administrator. And, above all, you would not want your brain specialist to find his decisions overruled by a layman or the hospital board. You would object if necessary equipment was lacking because of a budget cut, or if the lights or oxygen supply might be cut off because the hospital superintendent thought it would save money.

We let politicians take over

WILLIAM D McGUIGAN,
Assistant Director, Engineering Research Division
Stanford Research Institute

Interview by JENNESS KEENE, San Francisco

The individual is not to blame for the lack of long-term, creative research in this country; it is the fault of government and industry. The government will finance projects only if they are politically ex-

pedient, and industry will finance them only if there is an immediate payoff.

We are letting politicians call the shots. Research originates by government request and must be approved by Congress. Many decisions about what research should be done are made by politicians or civil servants who are not qualified to make them. There are some dedicated scientists in government, but most of them are in no way equal to their industry or university counterparts.

Objectives foisted on NASA are political, originated in Moscow; no worthwhile research manager would be a party to such a farce. Our own politicians, urged into defense programs of one kind or another by reports of Russian accomplishments, call in committees of experts from universities, and expect them to make decisions. But university research is unguided and undirected, and academic men are incapable of making such decisions.

In industry, most research is highly directed toward the product goals of the company. Industry wants competence, not creativity, and creativity apart from corporate lines is not really welcome.

What should a young man do who wants to go into serious research? Historically, he would have gone to Los Alamos, MIT, University of California at Livermore—when their projects started. They were major efforts on long-term endeavors with a national objective, and billions behind them. At the outset, these projects employed key staff members and could attract bright young men.

Today, a young man's best chance might be to go into a research institute—one of the few places outside government agencies in which the scientific staff proposes problems, and the administrative staff finds support for them. When a problem ceases to be interesting scientifically, the institute can go into a new field, or reorganize into new groups.

A man in research should work on a project about five years, then change. He will switch jobs often during his career; or he may change objectives often, with the same employer.

Many changes should be made. First there should be some laws, and one should be to limit the term on the scientific advisory council of NSF to three or four years. We should also start a research program on "How to get creative people to do long-range research." A careful study, done by others than politicians and educators, could design an intelligent national research program. This program should give research men freedom to select and pursue subjects without heckling, without questions of accounting (particularly if they happen to be wrong on the first guess), and with full public confidence.

Hunger for security

DR FINN J LARSEN,
Vice-president in charge of research
Minneapolis-Honeywell Regulator Co

Interview by E H SEIDL, St. Paul

The report of the "Conference on Research Goals" undoubtedly portrays the situation for most workers in industrial research and development. The hunger for security and the lack of imagination are undoubtedly common.

It is true that most of our engineers must perfect existing products and develop next year's models. But we do have a group of staff engineers who are assigned to explore the unknown in engineering, and we ask them to be imaginative, adventuresome, and uninhibited. They do creative work on entirely new kinds of control problems that have never before been solved.

In addition, our corporate research center has two principal objectives that are significant here. One is the exploration of entirely new fields for the company; the other, basic research in all fields of interest to us. These scientists are encouraged to follow the trails that the research work suggests. While such programs are carefully directed as far as budgets are concerned, the researchers enjoy considerable freedom as to scientific and technical direction.

Plodding is necessary

DR LAURENCE H SNYDER,
President
University of Hawaii

Interview by A A SMYSER, Honolulu

First off, I don't think things are quite as bad as they seem. We have taken long leaps; modern nuclear physics came about in just that way. But the objective is sound and it can be attained—by example. It can be done by giving every encouragement possible—including economic encouragement.

Any solid program of research ought to include a few screwballs—maybe 1% or 5% of the money you spend or the projects you support. Still, every major breakthrough in science has been based on much basic, plodding research. You don't just leap from crag to crag. You try to reach the crag, but there's a lot of plodding on the way.

One of my pet projects has been the study of tensions between people and groups. Not too long ago I encouraged this on a small scale at the University of Oklahoma, and already it has led to a science of "intergroup relationships" that is being expanded rapidly.

Several major sources of funds turned the idea down, until the Rockefeller Foundation finally gave it support. In the first project, boys at a summer camp were manipulated without their knowledge by scientists disguised as gardeners or janitors. They successfully built up and broke down tensions, bringing the boys to split into gangs that came close to rock-throwing, then bringing them back to friendship again. This study may yet lead to ending wars by the understanding and control of tensions between nations.

Industry can encourage "long leaps." It's possible to set up a crash program for one specific thing and get what you want. But every time you ignore those little sideroads that you need to follow in basic research you are missing something—and it may be something important.

Upgrade the colleges

DR DANIEL E NOBLE,
Exec Vice-president
Industrial, Semiconductor and Military Electronics Divisions
Motorola Inc, Phoenix

Interview by FRANK GIANELLI, Phoenix

An educational atmosphere conducive to science, and new standards of reliability through solid-state electronics—these are "breakthrough" building blocks for a better scientific future.

Responsibility for creating an atmosphere conducive to science begins at the high-school level. We have to eliminate the mystery surrounding the sciences and mathmatics and get far more students to study these courses.

We need to upgrade colleges. Motorola, for example, helped nearby Arizona State University in its transition from college to university status. We have supplemented state funds with an initial $150,000 grant to provide the salary for a man of national renown, endow a library, and to publish technical papers in electronics fields—

where texts, when published, are often 10 years behind the times.

Future engineers must be multiskilled: physical chemists, metallurgists, physicists, electronic specialists. The problem is to change the educational system fast enough to keep pace with these trends.

We have lost sight of a fundamental truth. Gimmicks and gadgets, monster cyclotrons, and double-supercolossal space missiles are overshadowing the need for the essential creative unit—the lone, disciplined human brain which must finally select and synthesize related elements into whole concepts of new-found truth.

Management must be more receptive

LT GEN JAMES M GAVIN,
President
Arthur D Little Inc

Interview by PAUL GIGUERE, Boston

Research funds, whether from universities, industry, or government, must be risked more courageously on the support of innovative men and women. So long as business administration is preoccupied with payoff on quick results, we shall not obtain major breakthroughs that may require, for example, five years to show application.

Management in industry and government must be more receptive to the new and unusual, more ready to look for the potential, in a novel idea. Our accounting systems and rewards are not geared to the rapid changes that this age of technology has forced upon us.

University professors, and those who support academic research, can help by seeking and encouraging the unexpected from students. Industrial research directors can secure breakthroughs only as rapidly and as frequently as they can cause their managements to see the potentialities of novel ideas. Professional societies can assist by rewarding the most intellectually daring of their members.

In reporting to the U S Navy last year on the proportion that it should devote to basic research—the area from which come the significant new discoveries on which technological advances are based—we pointed out that only 2% of the nation's scientists and engineers are engaged in basic research. Apparently the "insatiable desire to know and understand the universe in which we live" is an infrequent spark.

I do not believe that this "insatiable desire" can be taught. I am certain that the intelligent reception of its results can be improved, which would mean greater encouragement of those who possess this potentially creative urge. But this attitude of receptivity is not easy to come by.

Another study we made recently showed that (1) groups are generally hostile to change, (2) concern with immediate problems makes it difficult to become interested in radically new ideas, and (3) innovations are more easily recognized as valuable after their application.

Find a place for the oddball

MARTIN P CAPP,
Dean of Engineering
San Diego State College

Interview by PETER KAYE, San Diego

An undergraduate program leading to a BS in engineering contains a strong core of fundamental courses, because in four years, it is impossible to train a specialist. The emphasis here is on team operation. But the student who is motivated toward research can best find his inspiration through contact with a faculty member; there is no substitute for this personal interchange.

We have student chapters of major engineering societies where faculty and practicing members of these societies are constantly available to give guidance and inspiration toward a particular field. And there are programs with area employers to place pregraduates in part-time jobs.

In 1960, for the first time, San Diego State was authorized to give masters degrees in engineering in two fields—thermodynamics and machine design. We have more than 60 enrolled—most are employed engineers seeking to better themselves.

In addition, our engineering department contains physics and chemistry majors taking engineering courses. The physics majors—and we have the largest department west of the Mississippi—mostly are in electronics. These students are science-oriented, smarter and more inclined to research.

In our program, while concerned with the majority, we also try to find a place for the "oddball," whether he has a unique place in the field, or belongs in it at all.

An exciting time to live

HENRY J KAISER
Industrialist
Hawaii

Interview by A A SMYSER, Honolulu

Researchers are indeed faced by the challenge to take "long leaps" forward. Research and development have created our most fabulous industry—the new industry of discovery.

Thanks to promising pioneering research, this age can look forward to the production of unlimited energy from the sun . . . unlimited supplies of fresh water from the sea . . . unlimited raw materials and food produced synthetically . . . These could go far toward banishing human want forever, everywhere.

Beyond the splitting of the atom into a chain reaction of nuclear power, scientists now probe into the ultimate forces that control the form of the nucleus and thereby control all matter. They envision a "solar storage battery" that would accelerate the processes of plant biology and produce not only energy, but food and organic raw materials. What a challenge to our time—to open up sources of limitless power!

In use of metals, such as aluminum, so swift is the sweep of the light-metals age that in each year up to 1965 at least twice again as much aluminum will be used each year. Steelmaking is in the early stages of the greatest changes yet made to increase efficiency and lower costs.

Jet transports are shrinking world travel time by fully 40 per cent, and the next major breakthrough will fly us across the continent in two hours or less—around the world in a day.

From medicine will come a floodtide of discoveries on body chemistry and metabolism; the scourges of cancer and heart disease before long should be laid as low as tuberculosis and polio. Meantime will come an all-out attack against mental illness, and better treatment for the more than half of our illnesses which arise from emotions and mind—the psychosomatic ills. It will be commonplace for members of this generation to live to be more than 100 years old.

Quoting from a poem, "Today," by Angela Morgan:

"To be alive in such an age!
With every year a lightning page,
Where miracles are everywhere,
And every inch of common air
Throbs a tremendous prophecy
Of greater marvels yet to be.
To be alive in such an age!
When man—impatient of his cage,
. . . Reaches goal on goal—
Travels the earth from pole to pole.
O age with wings,
O age that flings
A challenge to the very sky,
Where endless realms of conquest lie!
When, earth on tiptoe, strives to hear
The message of a sister sphere,
Yearning to reach the cosmic wires
That flash Infinity's desires."

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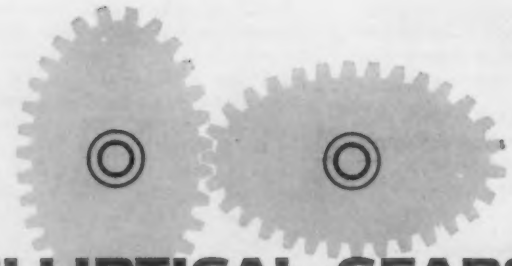

ELLIPTICAL GEARS for CYCLIC SPEED VARIATIONS

Like other noncircular gearing they offer advantages for high-speed operation. The fact that they can be made in identical twin pairs gives them a special advantage. Article develops handy design equations, works out two sample problems.

SIGMUND RAPPAPORT, *kinematician*
Ford Instrument Co, Div of Sperry Rand Corp, and Adjunct professor, Polytechnic Institute of Brooklyn

Though you can't get intermittent motion out of a set of elliptical gears, their popularity is growing. This is because they meet the need for speeding up automatic machinery. These speeds are becoming too high to permit an intermittent mechanism to come to a full stop. This is why today's preference is for a varying-speed drive that slows down periodically. If such cyclic motion is practical, the elliptical type has this recommendation—smooth cyclic motion with a minimum of sudden changes in velocity and imbalance. Many other types of noncircular gears (see "When You Need Noncircular Gears," Mar 14 issue) can give the same results, but the elliptical types are simpler. They can be made as twin pairs, and their contour can be approximated by a series of circular arcs. Both advantages reduce cost of manufacture.

Design Equations

The twin principle simplifies design. It is illustrated with the pair of identical ellipses drawn at right. They rotate in opposite directions: one around its focus F_1; the other around corresponding focus F'_1. When the gears rotate through angles θ_1 and θ_2, respectively, all points on arc MN come in successive contact with points of the equally long and identically shaped arc MP. Basic rule is that $R_1 + R_2$ must be constant. From symmetry, $F_1'P$ (which is R_2) equals F_2N; therefore distance $F_1N + F_2N$ is constant, which is the definition of an ellipse.

From this same condition the instantaneous angular velocity $d\theta_2/dt$ of the output gear easily be found if the constant input velocity ω is given. The instantaneous velocity ratio $(d\theta_2/dt)$: (ω) is determined by the inverse ratio of the instantaneous radii vectors:

$$\frac{d\theta_2}{dt} = \omega \frac{R_1}{R_2}$$

From the polar equation of the ellipse,

$$R_1 = \frac{a(1 - \epsilon^2)}{1 + \epsilon \cos \theta_1}$$

where ϵ (the numerical eccentricity of the ellipse) is defined as

$$\epsilon = \frac{\sqrt{a^2 - b^2}}{a}$$

with a as major, and b as minor semi-axis. This equation can also be written as

$$\epsilon = \frac{e}{a}$$

where e is distance from focus to center of the ellipse.

Symbols

a = major semi-axis
b = minor semi-axis
ϵ = numerical eccentricity
e = distance from focal point to geometric center of ellipse
F_1 = focal point and center of rotation of ellipse
F_2 = focal point of ellipse
K = ratio of velocity change of output gear
N = number of teeth
R = instantaneous radius
θ = instantaneous angle of rotation
ρ = radius for approximating the contour of ellipse
ω = constant angular velocity of input
Subscripts *1* and *2* relate to input and output elliptical gear, respectively, unless otherwise stated.

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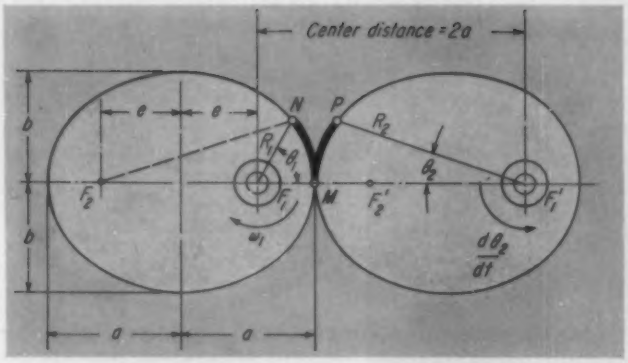
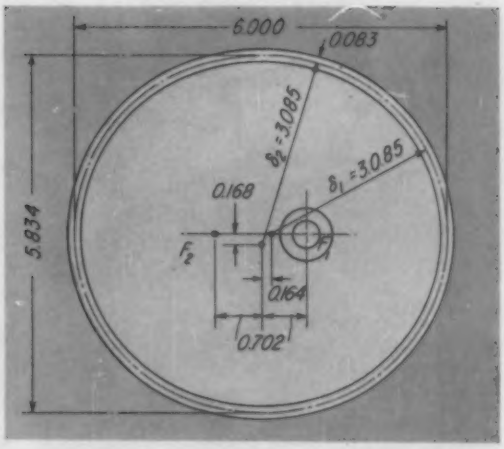


TWO IDENTICAL ELLIPSES rotating around foci F_1 and F_1', will have equal arcs MN and MP in successive contact.



DIMENSIONS OF ONE OF THE ELLIPSES for producing over-all velocity change of 2.6 per cycle.

From $R_1 + R_2 = 2a$, is it found that

$$R_2 = 2a - \frac{a(1 - \epsilon^2)}{1 + \epsilon \cos \theta_1}$$

$$R_2 = a\left[\frac{1 + 2\epsilon \cos \theta_1 + \epsilon^2}{1 + \epsilon \cos \theta_1}\right]$$

or

$$\frac{d\theta_2}{dt} = \omega\left[\frac{1 - \epsilon^2}{1 + \epsilon^2 + 2\epsilon \cos \theta_1}\right]$$

The extremes occur at $\theta_1 = 0$ and 180°, with $\cos \theta_1 = +1$ and $\cos \theta_1 = -1$. Thus, by substituting for ϵ, the minimum velocity at $\theta_1 = 0$ is:

$$\frac{d\theta_2}{dt_{(\min)}} = \omega\left[\frac{a - e}{a + e}\right]$$

and, for $\theta_1 = 180°$:

$$\frac{d\theta_2}{dt_{(\max)}} = \omega\left[\frac{a + e}{a - e}\right]$$

Maximum and minimum angular-output velocities are the reciprocals of each other. If K is the ratio of maximum to minimum, then

$$K = \frac{d\theta_2}{dt_{(\max)}} \Big/ \frac{d\theta_2}{dt_{(\min)}}$$

$$K = \left(\frac{a + e}{a - e}\right)^2$$

It is good practice to keep K under 5 to insure smooth running without "whip." Design usually starts with the choice of center distance 2a; in other words, with the size of the gears. If the major semi-axis a is given, and a certain over-all ratio K is desired, the minor semi-axis b can be found from

$$b = \frac{2aK^{1/4}}{1 + K^{1/2}}$$

Sample Calculations

PROBLEM I—Design for an approximate 2.8:1 velocity change

GIVEN: Exact center distance 2a = 6 in.

Approximate over-all ratio K = 2.8

Preferred diametral pitch (DP) = 12

Thus, a = 3, and

$$b = \frac{6(2.8)^{1/4}}{1 + (2.8)^{1/2}} = 2.905$$

Circumference of the pitch ellipse is approximated closely enough by $(a + b)\pi$, if, as in most applications, K does not much exceed the value of 4; that is, if the ellipse is not too flat. The number of teeth, N, of a given diametral pitch that can be accommodated on this circumference is the same that can be placed on an ordinary circular spur gear of the diameter $(a + b)$. Thus

$$a + b = N/DP$$

and

$$N = (3 + 2.905)(12) = 70.86$$

If an elliptical gear has an odd number of teeth, a space on one end of the major axis will be opposed on the other end by a tooth. This allows making the two mating gears identical—and cutting them simultaneously. Thus, choosing the nearest odd integer, the number of teeth becomes 71. Values for b and K must be adjusted:

$$a + b = 71/12 = 5.917$$

$$b = 2.917$$

Dimension e is

$$e = \sqrt{9 - 2.917^2} = 0.702$$

$$K = \left[\frac{3.702}{0.298}\right]^2 = 2.6$$

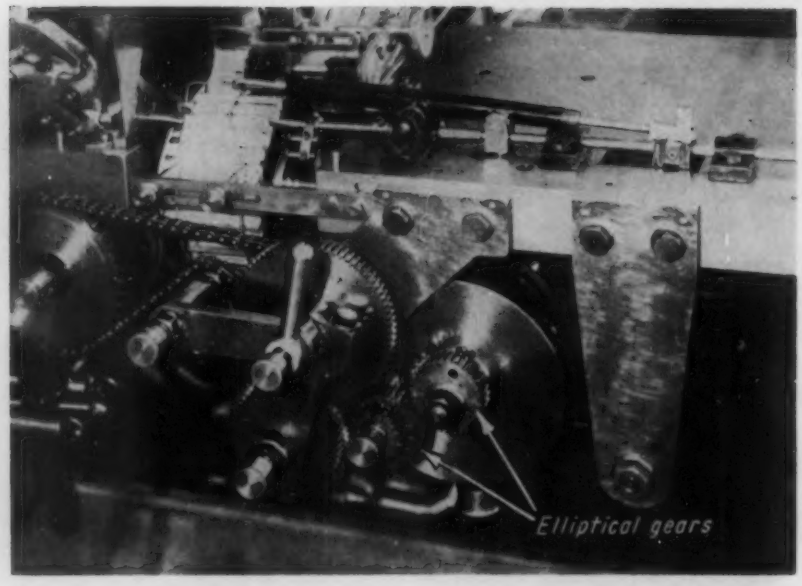
All dimensions determining the pitch ellipse are now known (see illustration above).

Outline of the gear blank is not an ellipse, but a curve equidistant from the pitch ellipse. The distance equals the addendum (in this case 1/12 in. = 0.083). It is often sufficient to treat this outline as an approximation and compose it of circular arcs, the radii of which are:

$$\rho_1 = \frac{b^2}{a} = 2.836$$

$$\rho_2 = \frac{a^2}{b} = 3.085$$

The addendum must be added to the radii to obtain



CIGARET MACHINE (in photo) employs elliptical-gear set designel by author for cyclic operation of tobacco cutter.

the radii of the blank. The larger radius can be turned or milled; the smaller radius is milled. Adjoining portions of the arcs can be blended in by hand filing. Teeth are cut with a form cutter, one space at a time, while the blank is held in a fixture which is rotatable around the centers of the radii. The starting cut is put on the major axis. Or any of the methods suggested in the previous article on noncircular gears can be applied.

PROBLEM II–Design for a given displacement ratio

The tobacco transport on a small European-design machine for mouthpiece cigarets (F Lerner Automatic Machinery, Vienna, Austria) had an intermittent drive to stop the transport while the cutter went through the tobacco. It was found sufficient merely to slow down the tobacco speed when the cutter whips through it, and replacing the intermittent drive by a pair of elliptical gears (see photo above) gave an appreciable increase in output speed.

Requirements: When the driver turns through 120°, the driven gear shall turn approximately 180° and shall complete its full turn when the driver goes through its own remaining 240° (see diagram). Center distance is 5 in. (hence $a = 2.5$); $DP = 10$.

It follows from the geometry that

$$\overline{F_1F_2} = 2e = \tfrac{1}{2}\overline{F_1S}$$

$$\overline{F_1S} = 4e = 4\sqrt{a^2 - b^2}$$

and from the fact that the angle $F_2F_1S = 60°$

$$\overline{F_2S} = 2\sqrt{3(a^2 - b^2)}$$

But the ordinate in the focus of an ellipse is

$$\overline{F_2S} = b^2/a$$

Therefore

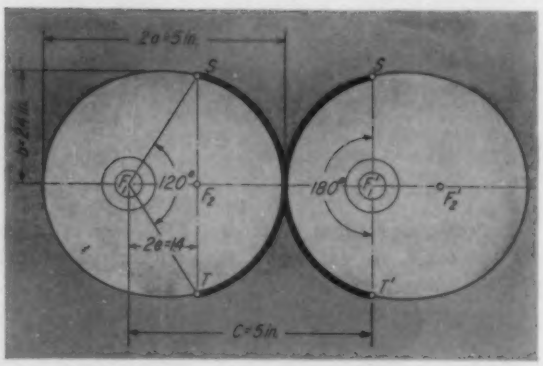
$$b^4 = 12a^2(a^2 - b^2)$$

Substituting for $a = 2.5$ and solving for b gives

$$b = 2.408$$

Diameter of a spur gear which has the same circumference is

$$a + b = 4.908$$



from which the number of teeth is

$$N = 10(4.908) = 49.08$$

Nearest odd integer is 49. Again adjusting b gives, $b = 2.4$. Thus

$$e = \sqrt{2.5^2 - 2.4^2} = 0.700$$

From this all other dimensions are determined.

For REPRINT of above article, just check P40 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE—For other methods of obtaining cyclic speed variations, see:

Cam Control Gets More Out of a Planetary Gear, Jan 4 '60, p 38. By incorporating a grooved cam, a novel mechanism is obtained that's able to produce a wide variety of output motions.

New Equations Locate Dwell Position of 3-Gear Drives, June 8 '59, p 80. These drives can produce three different motion patterns—depending on how far the output gear is located from the input gear. Equations pinpoint this all-important dimension.

Cams and Gears Join to Stop Shock Loads, Sep 16 '57, p 84. Intermittent mechanism employs a rotating planet-cam to reduce acceleration and deceleration peaks.

In consumer products—

Focus DESIGN on "TREMENDOUS TRIFLES"

Granted that you're offering a well-engineered piece of equipment . . . but that isn't enough. Acceptance by the public depends not only on broad design concepts but on the attention you pay to incidental features and details. Author shows how it's done with a most criticized American product—the family car.

I. H NAGLER, *staff engineer*
Office of Director of Engineering
American Motors Corp

When a product reaches the advanced state of development typical of many popular home appliances and consumer goods, a revolutionary new design concept is rare. For the most part, you can't rely on the research lab to come up with a basic improvement that will insure your product's success by creating overwhelming customer demand; breakthroughs are too uncommon. This is particularly true in the American consumer market—probably the most discriminating market in the world. Product success often depends to a large extent on trifles—minor matters the engineer might ordinarily be inclined to dismiss as trivial details.

The public is quickly satisfied that fundamental engineering concepts are acceptable and soon turns to less important criteria to discriminate between the product they judge to be of "high quality" and the one that is evidently "the result of second-rate engineering." Customer complaints illustrate this: grievances commonly center around details exaggerated out of all proportion to their functional importance.

Like it or not, your reputation and the reputation of your company often rests on how much of this "quality" you are able to incorporate into your product. It isn't enough that a part be designed to withstand any service load that is likely to be put on it. It must also look strong. The determined consumer will apply the most bizarre kind of test to expose poor design, shoddy workmanship, corner-cutting production. In the case of one well-designed foreign car, it is possible to lift the deck lid and, with one hand at each corner, twist it to show flimsy construction. A scoffer is unmoved by arguments that the lid would never be subjected to this kind of a load in service and that it always seats perfectly even after such rough treatment. It's an inferior product and that's that.

How do you discover these nonfunctional but all-important details? Basically, it's pretty much a matter of home-brew psychology, common sense and guesswork. The designer who reworked the hi-fi control panel—reducing the number of controls to a minimum, striving for a clean, functional appearance—was asking for trouble. He wasn't aware that the quality of a sound system is often judged by the number of knobs and dials.

Market research—essentially a poll of potential purchasers to find what they want—is one way to avoid such failures but it's not always successful. Nor is its more modern relative, Motivation Research. What a man thinks he wants, and what he really wants—and eventually buys—may be two very different things. Going beyond this, the Motivation Researchers have tried an even more indirect approach; they ask the man what he thinks his neighbor wants. But the results aren't much more encouraging. "Motivation Research," says one marketing man, "only confirms former suspicions. In the consumer market we're dealing with a thoroughly unpredictable situation."

The attention paid to detail design in automobiles illustrates the critical importance of this matter in all marketing to the consumer. Of all American products, none is more analyzed, poked, prodded, pinched, tortured, abused, cussed, discussed. Major design changes make less of an impression on the owner than the little features that show thoughtful engineering consideration. Following is a list of those "tremendous trifles" (exclusive of styling factors) as applied to our favorite home-away-from-home. Do they suggest some areas needing attention in your designs?

A CHECK LIST

Controls

Are controls conveniently placed, easy to operate, distinctively marked? Many automobiles, as well as other consumer products, have been poorly planned from this standpoint in the past. But recent models show instances of thoughtful application of the "human engineering" so popular of late in design of aircraft and machine tools.

"Confusible" controls have appeared on some production automobiles—one had the heater and light switches mounted adjacent to each other, occasionally causing the driver to turn off lights when he wanted to reduce heat. This was corrected by interchanging light switch with windshield wiper control. Round knobs may be undesir-

able for some lever controls but knobs with sharp edges and dangerous projects should be avoided.

Lighter and ashtray, if poorly placed, will force an habitual left-hand smoker to shift to right-hand smoking (and vice versa). Further, the lighter should be mounted away from other push-in controls; and ashtrays should go where—when open—they will not injure passengers thrown against them. Also, ashtrays should be kept away from air vents or other areas likely to be swept by air currents when windows are open.

Accelerator-pedal pressure should be neither so heavy that it requires muscular effort to depress, nor so light that it becomes tiring to hold up the foot. Pressure buildup, controlled by spring geometry and linkage design, should be within reasonable limits. Angle of pedal and crosswise tilt should be adjusted to align with the foot when resting in a normal position. Consideration should be given to milady's high heels. A pedal too high off the floor may allow a spike heel to slip under the lower edge.

Horn ring is one of those items that get a great many complaints from the driving public—far more than it deserves. A compromise is usually necessary between horn ring function and vision. A 360° type can be found easily when turning a corner—but usually it obscures instruments. Present practice favors an open-top horn ring. Horn buttons will continue to be acceptable on low-price models.

Interior

Feel of the upholstery is an intangible factor but one by which many prospects judge the quality of the car. Unfortunately, a well-upholstered, soft-feeling seat may not give a comfortable ride.

Sound of doors when slammed is another test many people use to judge sturdiness of the coachwork. A good, solid sound can be had with adequate sound-deadening material on inside of the door. Feel of the door as it swings on its hinges should be firm and smooth; this is related to detent action of hold-open, design of over-center springs (if present), and action and sound of latches. In the hinge area, avoid rough, unfinished surfaces and openings for concealed hinges.

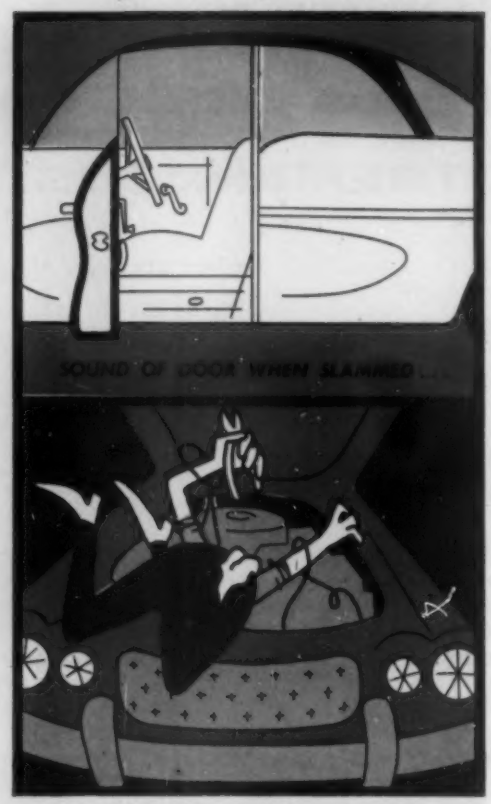
In the trunk, projections and sharp corners can damage luggage. This includes tire and jack hold-down, projections on hinges that can dig into luggage when trunk is nearly full. The latch mechanism can also cause damage when luggage is dragged over the rear sill. If tire is located on floor of trunk, it should be covered with a rigid lid to give better support to luggage.

Jack stowage should be made convenient and free from rattles. When hold-down springs are needed, design them for operation by a driver with normal physical strength. Jack should be stowed off floor to avoid premature rusting.

Exterior

Bumper height was standardized by SAE in 1947, but is not mandatory for the industry. Standard is 18¾ in. The bumper must not dive below or rise above this height during extreme maneuvers—otherwise there is risk of locked bumpers and damage when the car is pushing or being pushed. The standard is now being reviewed to determine if updating is desirable.

Among other things, an automobile



ACCESSIBILITY OF COMPONENTS . . .

Road clearance of 6 to 7 in. (unloaded) in recent years has been pretty well standardized through the industry. But check for low overhangs, front and rear, that will cause difficulty when approaching and leaving a ramp. Low, exposed under-car parts such as gas tank and rear axle can give unsightly appearance when viewed from following automobiles.

Sound of exhaust is mostly a matter of personal opinion, but is often a factor used to judge the quality of the car. A "high quality" sound may have no relation to decibel readings and sometimes the customer favors a muffling characteristic reminiscent of controlled power rather than a greatly subdued sound with low noise level.

Safety

Because it adds little to the sales value, safety equipment that excessively boosts manufacturing costs is seldom justified. Also many alleged safety devices have not proved effective and practical in actual use. Yet a safe design, usually costs no more than one with recognized hazards. Data from crash tests and analysis of thousands of highway accidents have resulted in many design recommendations. But all too frequently, the principles of safety in automotive design are sidetracked or overlooked when faced with styling or manufacturing considerations.

Of those safety elements that cost little or nothing extra, check design for hazards such as: (1) unyielding

is judged by . . .

QUALITY OF THE SEATS

panels where light, collapsible metal or crash pads–able to absorb 150 to 300 lb, impact loading–will prevent injury; (2) inside mirror–avoid excess rigidity in mounting and consider injury hazard if support is fractured; (3) steering wheel hub–recess several inches below rim, or provide large-area crash surface, currently the recessed hub design is most popular but value in actual service is yet to be firmly established; (4) rear edge of seat back–should be rounded or padded to avoid injury to rear-seat passengers; (5) sharp projections on hood, trunk lid, grille, bumpers. (Sharp hood ornaments, also a hazard, have been overemphasized by consumer publications and safety do-gooders. General industry practice is to minimize or eliminate hood ornaments.)

Sharp edges under the hood or around the gas filler pipe are dangerous for service station attendants and may spread a bad reputation about specific makes. Unfinished corners on the back side of grille bars, bumper guards, fenders, may be unexpectedly hazardous for owners who wash their own cars.

Maintenance and Servicing

Representatives of the auto industry meet periodically with members of the oil industry, service station personnel and suppliers of auto parts to discuss problems in connection with maintenance and servicing. Pointed out at such conferences have been:

Dipsticks that show exact amount of oil to be added. Markings are recommended by SAE, but have not yet been widely adopted by manufacturers. Engine-oil dipstick and transmission dipsticks should be color- or shape-coded to avoid confusion, and the same code applied to drain plugs.

Gas filler pipe should be designed to prevent spit-back at delivery rates up to 15 gal./min (max for modern service station pumps). A "vent ratio" of 4:1–a 4-in. fill-pipe and 2-in. vent, for example–is used for underground tanks, in service stations but a higher ratio probably will suffice for most automobile gas tanks.

Service station hoists are now commonly of the single-post, frame-engaging variety, but are questionable for lifting some automobiles because of weak flanges in the area normally contacted by the lift. Independent rear suspension, found on some foreign cars, also gives trouble with this type of lift. Jack pads, built into the frame or body understructure, at appropriate points, will eliminate this difficulty.

Accessibility of filter, sparkplugs, distributor, generator, valve tappets is occasionally poor, resulting in many complaints. On some cars, oil filters have been poorly placed and difficult to replace, and oil filler pipes are almost impossible to reach without spilling oil over the engine unless special filling equipment is available. Distributors should be placed away from hot engine parts and clear of accessories that block access. It should be possible to check radiator level by looking in the filler neck; this is sometimes blocked by inlet baffles in the upper tank.

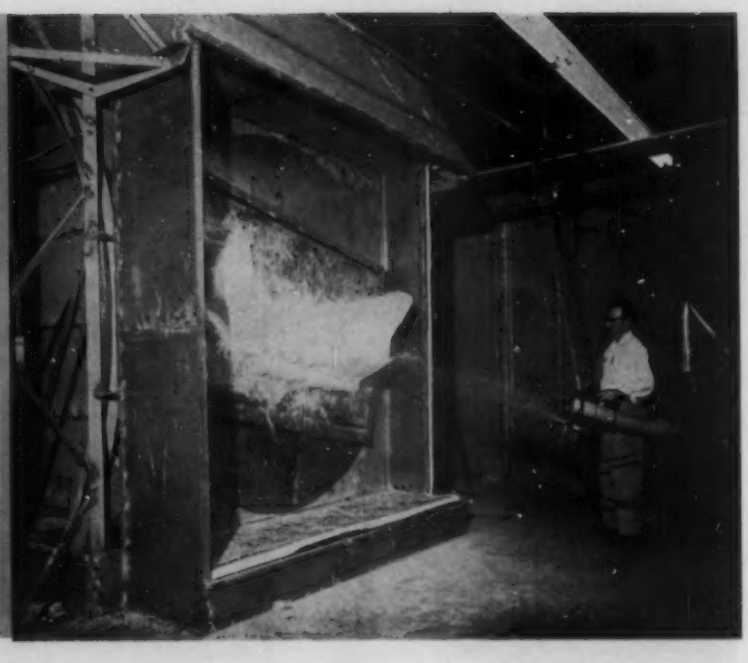
License plates are now all the same size (6 x 12 in.), permitting design of plate holders as an integral part of the car to improve appearance and minimize loss and theft. Consideration should be given to locating the plate where it will not be damaged–a likelihood when plates are in center of bumper.

Bumpers should be designed to match the towing rigs often applied to front or rear. In automatic car-washing establishments, a hook is usually attached to the front bumper to pull the car through the wash. Combined grille-and-bumper designs and center-mounted license plates frequently interfere with this hook. Bumper clamps (for trailer tows and towing of 3-wheel delivery vehicles) require a well-defined upper and lower edge on bumper face bar and minimum interference from splash shields. Many service stations have floor hoists which lift the car by the bumpers. Here also interference from splash shields is to be avoided. When a service truck does the towing, the car is usually suspended by the front or rear bumper–so it should be strong enough to withstand this kind of treatment.

Serviceability too frequently has been accepted as a low-priority phase in car design, suffering from emphasis on styling, performance and customer convenience. However, it has an indirect bearing on product reputation and customer acceptance, if for no other than nuisance factor: replacing a 5¢ fuse in an inaccessible, hard-to-find location may require 20 minutes' time, accompanied by uncomplimentary remarks from the service attendant. It is well to remember that most servicing is performed by gasoline stations or independent shops, and they may be unfamiliar with specific makes of automobiles. ■

What Is Air Preforming?

Air-preform process forms chopped strands of glass fiber into a blanket that is shaped like the part to be molded. Either the plenum-chamber or the directed-fiber system is used. Both systems create a suction behind a rotating screen that conforms to the part shape. Plenum-chamber system floats glass strands down onto the screen. Directed-fiber method gives better fiber distribution when the part is large and highly asymmetrical or complex. With both techniques, suitable binders are applied during and after the cycle to make the preform easy to handle. Preform is then oven-baked to strengthen it for further handling and prevent washout of fibers during the molding cycle. Final part is made by fitting the cured preform into matched-metal dies, adding catalyzed resin, and press-curing.



for lowest cost fiberglass-reinforced plastics. . .

AIR PREFORMING WITH MATCHED-METAL DIES

Whether you preshape the reinforcement or use flat mat, air-deposited fibers are the cheapest form of glass you can build into your part. Here's how to design molded structures to take advantage of this economy for production runs from 500 pieces up.

MORGAN MARTIN, *engineering vice-president, Molded Fiber Glass Body Co, Ashtabula, Ohio*

Although fiberglass-reinforced plastics have many advantages, they are more expensive than steel or aluminum—and will likely remain so, even though costs of resin and glass are coming down. Despite this cost disadvantage, there are two ways to keep your FRP-part costs in line:

- Specify the most economical fabrication process you can find.
- Engineer your part precisely for the minimum amount of mix.

Air preforming, combined with matched-metal die molding, is the most economical fabrication process yet developed for shaping fiber reinforcement of high-strength parts in commercial-volume production. This article, which explains the process and relates it to design, shows how to utilize it to get the most out of each pound of FRP you buy.

In the photo above, chopped glass strand is being blown with compressed air onto a screen shaped like the part to be molded. This is one of two methods (see "What Is Air Preforming," above) for preforming the glass reinforcement for deep-draw, complex parts. In practice, air preforming is broader than this: many highly complex parts that are not deep draws can be made directly from air-deposited flat blankets of fiberglass alone. Called glass mat, these blankets are made in three main types for successively deeper draws. Where a part contains both medium and deep draws, one of the mats can be used for

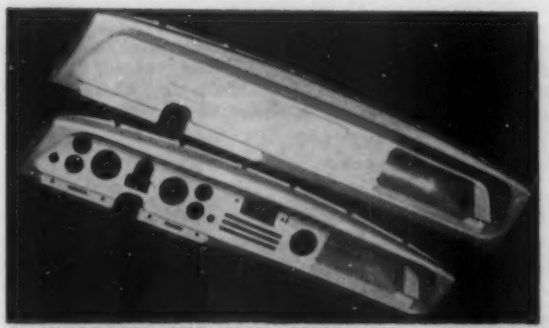
TABLE I—FOUR KINDS OF REINFORCING MAT

1. . Bonded Mat—chopped strand (½ to 2 in. long) of glass fibers loosely bonded together with adhesives into a flat mat weighing ¾ oz or more per sq ft. Several layers can be put into the mold at once. Used for parts with little contour or draw. Lowest cost mat.

2. . Swirl Mat—continuous, stranded glass fibers mechanically deposited directly from the melting process through orifices onto a moving mesh belt, in a swirl pattern. Weights run from 1 to 2 oz per sq ft. Mat is bonded loosely with adhesive. Used for parts requiring more draw than practical with bonded mat. More expensive mat.

3. . Needled Mat—chopped strands deposited on light, open-mesh cloth and mechanically embedded in the cloth by a felting or needling process. Weighs from 1 to 6 oz per sq ft. Has less noticeable fiber color than first two, but noticeable needled-fiber pattern when molded, because less binder adhesive is added. Used for all but deepest draw—where air preforming is required. Most expensive mat.

4. . Surfacing Mat—individual glass fibers, not stranded together, laid down with a small amount of binder to form a thin, easily draped mat or "veil." Supplied in thicknesses of 10 to 30 mils, weighing ⅛ to ¼ oz per sq ft. Adds little strength, but keeps coarser glass-fiber strands below surface, thus improving appearance by creating a resin-rich finish.



1. . PREFORM AND MAT COMBINED in Studebaker Hawk instrument panel allows part to have both deep-draw portion (glove compartment at right) and moderate-draw sections (balance of part), while retaining the economy of mat for most of the reinforcement. Holes for instruments and fasteners are punched immediately after molding (lower part).

TABLE II—MECHANICAL PROPERTIES OF PRESS-MOLDED FRP
(polyester resin with mat or air-preform reinforcement)

Glass content, %	25–30	35–40	45–50
Filler content, %	40	30	10
Tensile strength, psi × 1000	10	18	24
Flexural strength (dry), psi × 1000	25	35	45
Flexural strength (2-hr boil), psi × 1000	20	30	36
Flexural modulus (73 F), psi × 10^6	1.25	1.50	1.80
Flexural modulus (180 F), psi × 10^6	0.35	0.55	0.90
Flexural modulus (2-hr boil), psi × 10^6	1.00	1.20	1.45
Tensile modulus (73 F), psi × 10^6			
Reverse impact (room temp), in. (Values are for 0.100-in thickness)	7	9	11
Izod impact (unnotched), ft-lb/in.	18	22	25

the shallower parts and an air preform for the deep portions, Fig. 1. A fourth type of air-deposited mat, surfacing veil, can be added last to cover the fiber pattern (see Table I).

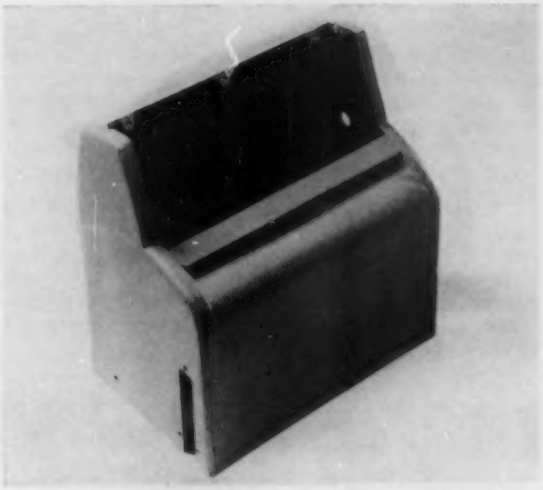
Choice of Materials

The proportion of reinforcement—whether air preform, mat, or a combination of the two—can be varied from 15 to 50% by weight. Mechanical properties and cost both increase as more glass is added, and above 40% glass the fiber pattern becomes prominent. General-purpose parts use 25 to 30% glass, while automotive parts run from 35 to 40%. Other processes use reinforcements such as glass cloth or continuous filament, and can thus attain much higher glass loadings—with proportionately higher properties and cost. The denser reinforcement forms don't draw well enough for matched-metal die molding, however.

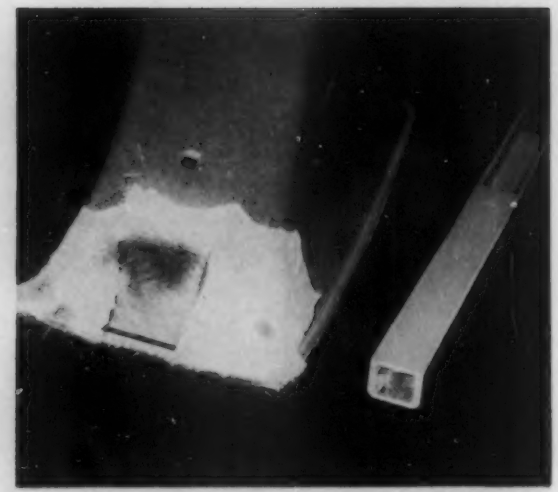
Polyester resins, obtained by reacting selected organic acids with glycols, are the most common FRP molding plastics. Different properties can be obtained by varying the acids and glycols: resins can be made rigid, semirigid, or quite flexible. By juggling resin rigidity, glass content, and inert fillers (added to reduce cost, shrinkage, and crazing), considerable variation in properties is possible.

There is no one ideal combination. However, structural parts, like auto-door pillars, are made with high glass content; high-reverse-impact parts, like fender skirts, need a medium glass content and a more flexible resin. Adding-machine housings, requiring high surface gloss but no exceptional strength or flexibility, call for a lower glass content, higher filler content, and a more rigid resin. If a baked-paint finish is required, a high hot-strength, craze-resistant resin is selected.

The properties given in Table II are for molded parts



2. . TWO KINDS OF LOCAL REINFORCEMENT are combined in this housing for an automatic coin changer. Interior-side boss gets its glass from preform; three bosses along the upper edge are polyester premix compound, inserted in special die cavities before the preform is put in place. Threaded-metal inserts in upper bosses are added after molding.



3. . WIRE AND WOOD ADD STIFFENING when embedded in molding. At left, wire frame is laid over preform of loudspeaker horn to stiffen free edge; a second layer of chopped strand (pulled back here for inspection) covers the wire before molding and holds it in place. At right, bowling-pin sweep is cut away to show hickory core added to prevent bowing when pins are cleared off the alley.

made with a semi-rigid resin and an aluminum silicate filler. Reverse-impact resistance is a special property that measures the ability of a laminate to withstand localized blows on one surface without damage to the other surface. An example would be stones hitting the underbody of an auto. Under these conditions, the material must be flexible enough not to craze on the reverse, finished side. In this test, a half-pound ball of 1½ in. dia is dropped onto a clamped disk of the material 5 in. in diameter. The reverse side is examined for fiber loosening with standard dye penetrants, and minimum drop height producing permanent stain is the reverse-impact value for that material.

Design Factors

After selecting the right resin-glass-filler combination for the environment expected, the geometry of the part must be established. This follows rules that depend partly on the method of shaping the preform and partly on its behavior in the molding cycle. Experience with air-blown preforms and mat reinforcement in metal molds has shown the following factors to be important:

• **Thickness variations should be minimized** to avoid resin-rich areas, where strength is lower and shrink marks may show up. A good rule is to keep the wall of the thickened area less than 1.5 times the nominal wall section. If this must be exceeded, the area to be reinforced can be thickened with strips of mat. If this is done in the die, the precise area must be easily identifiable and accessible to the press operator. Often, such thickening is added to a preform by letting air suction hold it in place and locking it with a topping layer of blown strand and binder. Either way, areas strengthened this way should not exceed 3 times the nominal part thickness.

Recommended thickness extremes for most custom-molded parts are: minimum 0.050 in., maximum 0.250 in. Typical tolerances, easily held on both thickness and contour, are: ±0.010 in. Most common thickness: 0.100 in.

• **Local reinforcement,** sometimes achieved by building up layers on the preform as described above, is best built into the part by other means. Most common method is to make the stiffener or boss of polyester premix (see PE—Oct 12 '59, p 86). Here, a recess is cut in one die and precompounded polyester-glass mix (or "gunk") is inserted before the preform or mat is laid in the mold. Normal curing cycle then molds the stiffener or boss in place, Fig. 2. Differential shrinkage between the part and the premix insert may cause sink marks; correction for this is undercutting the other die slightly, and sanding smooth after molding. All parts with premix inserts require painting for uniform color. Other local reinforcements include hardwood or wire inserts, Fig. 3.

• **Draft must be included on all parts,** and undercuts cannot be molded. Usual minimum draft is 2°, though 1° can be had at added expense. It costs more because the part is harder to remove from the mold, thus slowing the production cycle. Areas of zero draft have been designed into parts successfully, but the shrinking of polyester resin in cure makes some draft mandatory in most parts.

• **Surface ripples sometimes occur,** and are caused by localized shrinkage away from the die. Such areas, called

4. . SPECIALTY DECORATIVE EFFECTS can be added to surfacing-veil mat. Shown here are four of the many patterns possible. Veil, which hides coarse fiber pattern and presents a smooth surface, is laid over preform after the catalyzed resin has been poured into place. Patterns of this type add to cost of finished FRP part.

"lakes," are usually duller than where the resin has cured against the die. This condition is particularly undesirable when the surface is to be painted, or where the surface is large and flat. In these cases, specify a satin finish on the part so that the difference in finish will be less noticeable. Variations of this type are much less severe and less frequent here than in premix molded parts.

• **Finish on colored parts can be varied considerably.** Fiber pattern shows up most in pigmented parts. It can be practically eliminated by enamel applied directly to the as-molded surface of unpigmented parts, by adding fillers, or by adding surfacing veil mat to pigmented parts. Specialty decorative effects, Fig. 4, can be added to the veil—though at added expense. If a metal-like finish is desired —sanding, priming, and finish painting are recommended. Resins can be specified that will take paints that bake at 235 to 250 F.

• **Sharp corners should be avoided,** since the glass fibers are too stiff to bend into the corner area. Thus the exterior corner is resin-rich and may craze, though this is less of a problem with the newer isopthallic resins. Minimum inside radius should equal the nominal thickness of the part. A good rule of thumb is a minimum radius of $\frac{1}{8}$ in. wherever possible.

• **Edges are usually hidden in assembly** or turned out of sight with a rolled flange. If neither of these techniques applies, and the edge must be free, it can be covered with a snap-on extrusion. Note that, because matching die halves "telescope" together in the vertical plane to pinch off the excess preform or mat, the edge will never be square with the surface of the part—except where the surface is horizontal. Thus, where two parts of a continuing curved surface (an auto trunk lid and body, for example) must meet squarely, the as-molded edge must be ground after molding.

• **Reverse pinch-off should be avoided** where possible. A flange that changes direction creates a condition where the telescoping pinch-off (where one die slides into the other) must be reversed. At the point of reversal, proper sealing of the dies is difficult to attain. Parting lines should always be as horizontal as possible, too, as the line becomes more vertical (assuming vertically closing dies). Pinch-off tends to drag the preform or mat instead of shearing it cleanly. To avoid vertical pinch-offs, design the part so that two can be molded in one piece and cut apart after molding. Or an extra, throwaway section can be added, to be cut off after molding.

• **Low-production runs can be handled with epoxy tooling,** up to about 1000 parts. As-molded finish obtained is not as smooth as with metal dies—simply because epoxy dies are more porous. A dull, satin sheen or a flat, matte finish is common, as shown in Fig 5.

Close-fitting metal pinch-offs inserted to hold the resin in are generally not practical in epoxy dies, so that full press pressure is not exerted on the resin. This increases porosity in the finished part. Design of parts for plastic dies is no different; almost any shape moldable in metal dies can be handled. One major exception is in size; the very large parts made in metal dies, like boats and truck roofs, are not feasible because the dies won't take the molding pressures involved. Another exception in design is that premix inserts cannot be used for local stiffening, as in metal dies. Epoxy dies are usually not heated;

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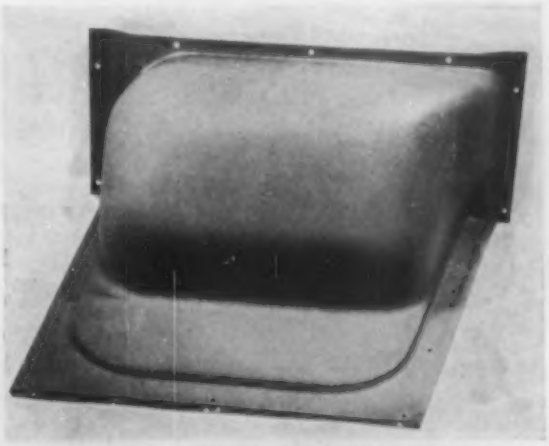
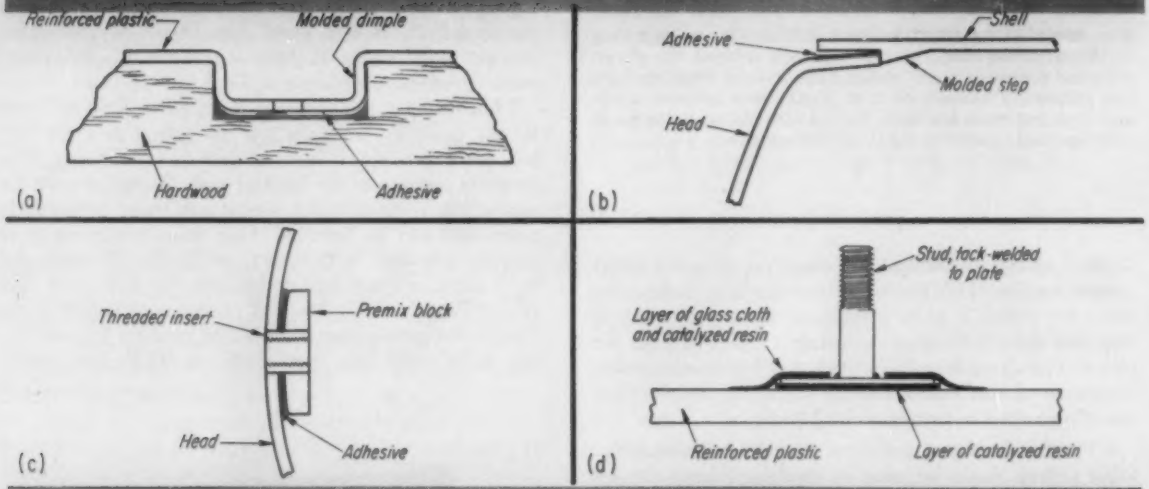
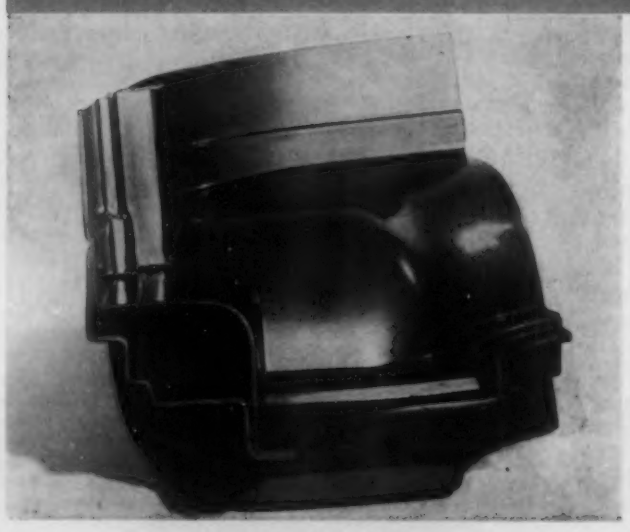


5. . SHORT-RUN PARTS like this GMC diesel-engine housing, made by Roller Reinforced Plastics Co, are made in matched epoxy dies at much less tool cost. Parts made in this kind of tooling are designed no differently from those for metal molds, except that glossy, as-molded surfaces cannot be achieved, and premix inserts cannot be specified. Plastic tooling of this sort can cost less than $1000.

6. . EXTREMES IN SIZES POSSIBLE in air-preform parts molded in matched-metal dies are shown in these two examples. Background: underbody for Chevrolet Corvette sportscar. Foreground: housing (with its preform) for recessed gas tank filling cap on all-FRP truck body.

7. . FOUR UNUSUAL CONNECTION TECHNIQUES for FRP molded parts: (a) Dimple firmly anchors adhesive-bonded wooden stiffener in place. (b) Cross-section of tank head-shell junction shows proper way to design telescoping joint; without taper, adhesive would be forced out as head was slid into place. (c) Premix stiffener, carrying threaded metal insert, is adhesive-bonded to tank head. (d) When a wall cannot be punctured, male connector can be locked in place with layers of glass cloth impregnated with resin, and cured with heat lamp.





8. . COMPOSITE SECTION OF SEVERAL MOLDED PARTS in this truck-roof corner shows the proper way to design adhesive assemblies: all surfaces to be joined should be capable of being brought together in a clamping direction, rather than in a sliding direction. Otherwise, adhesive may be forced out of the joint.

greater use is made of interior, exothermic heating for cure of the part—thus insufficient heat is available for curing the premix insert. Epoxy dies can be internally heated in special cases, but this adds to cost.

• **Size of parts suitable for air preform** or mat reinforcement varies widely. Largest part now being made is a 17-ft boat hull; smallest is a gas tank filler housing, Fig. 6, shown with Corvette underbody—another large part. Limitation on small parts is ability of the air gun to lay down glass in small areas without bridging, or the capacity of commercial mat to draw over small shapes without wrinkling.

• **Assembly of parts to themselves or to metal components** generally follows standard practice for all-metal structures. Self-tapping screws are most suitable, since a part is usually thicker than a metal part of equal stiffness. Rivets are widely employed, particularly those styles that do not require bucking bars. Polyester-based adhesives are often specified, either with or without additional mechanical fastening, provided the localized stresses in the joint do not become excessive (see PE—July 7 '58, p 64). In pure shear, the most desirable loading, a lap joint width of 10 to 15 times the material thickness (per inch of bond), will give a bond strength equal to the tensile strength of the reinforced plastic. Four unusual methods of joining are shown in Fig. 7.

• **Composite sections,** built up from two or more moldings, have unusual bending resistance because the greater material thickness (compared to steel of equal stiffness) gives a higher slenderness ratio. Thus, a box beam will fail on the tension side well before the compression side buckles. Sections constructed from pieces with compound curvature, Fig. 8, are common in truck structural members.

• **Molding interior holes** is a matter of judgment and common sense. Small (up to about 5 in. dia) round holes are much more easily and cheaply punched after molding. Large, irregular holes are usually easier to rout after molding, though a hole as large as the trunk opening in an auto rear panel is easily incorporated into the die.

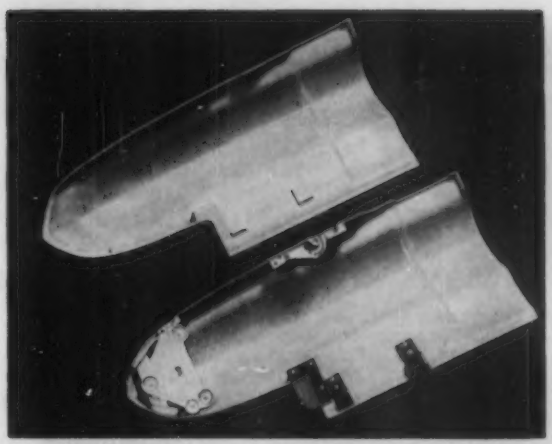
What's Ahead

There are several developments underway designed to build more economy into air-preform parts. These three are most significant:

• **New isopthallic resins** are being formulated to give better wet strength and corrosion resistance, along with improved resistance to creep and crazing. It is expected that these formulations will be substantially cheaper to make, thus making FRP parts cheaper to build.

• **A paint-finishing system** has just been devised to eliminate expensive surfacing mat, and offer primed surfaces equivalent to steel precoats in adhesion characteristics and smoothness.

• **Ferris-wheel-type preforming machines,** like the one shown on the first page, are being developed to make preforms more uniform and compact. This is done by maintaining constant pressure on the preform throughout the cycle. After the preform is shaped, it indexes upward—with suction maintained—into an overhead oven. Thinner preforms thus produced do not tend to wrinkle as much as do preforms made by older techniques—a major problem, until recently.



9. . MECHANISMS ARE BUILT UP just as they are in metal assemblies, except that adhesive-bonding becomes a major joining method. Here, a section of a "boot" for a Lincoln convertible top is shown in two stages of manufacture. At top, boot shell has been molded. Note premix inserts for mounting bosses. Below, lever mechanism subassembly has been bonded in place; black metal stops are fastened with self-tapping screws. Note that some of the subassembly parts are metal, others are polyester premix.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE: This is the sixth in our continuing series of detailed articles on the seven basic processes for fabricating fiberglass-reinforced plastic parts. The first five articles in the series, and a special report that identifies and compares all seven processes, are listed below:

Choose the Right Process for Fiberglass-reinforced Plastics, Jan 11 '60, p 47—Special report selects 7 key processes out of the 15 available, explains their strong and weak points, and shows how one or the other becomes the logical choice in most commercial-volume applications.

Filament Winding Grows Up, July 20 '59, p 46—After several successful years in the aircraft industry, this high-speed process is ready for more work. Article gives rules for design.

Design Must Be Different for Polyester Premix Molded Parts, Oct 12 '59, p 76—They can take the place of metals in many applications, but design follows different rules than for unreinforced plastic molded parts.

Sprayed Reinforced Plastics, Feb 8 '60, p 41—In the two highly competitive years since it was introduced, spray-up has become an economical process for making large parts from fiberglass-reinforced plastic. And it's bidding to produce smaller FRP parts too. How to design for the process.

Wet Slurry Brings Precision to Reinforced Plastics, Feb 22 '60, p 51—Making preforms by dunking the shape you want into a slurry of fiberglass and cellulose gives improved control over thickness, density and surface.

Contour Weaving Gives 3-D Preforms for Reinforced Plastics, Mar 21 '60, p 47—Newest process for shaping fabric reinforcement gives high glass content, continuous fibers, and controlled glass distributions—three advantages hard to find in conventional processes.

inductive "reactor" and a capacitor combine to control speed without slowdown under load . . .

New Variable-speed Motor Drive

Add the simplicity and efficiency of a conventional variable-transformer drive to the speed-regulating advantages of a thyratron drive—that's what the reactor-capacitor offers. Here, it's described for the first time.

ARAM KALENIAN, *president and chief engineer*
Vee-Arc Corporation, Westboro, Mass

SERENDIPITY

Aram Kalenian invented the reactor-capacitor control (Vee-Arc Corporation's "Reactron") described in his article. He did it by what looks like a fine example of serendipity. He hadn't set out to invent such a control. He was only searching for some combination of conventional control elements that would drive a disk grinder—one of Vee-Arc's products—at reasonably constant speed.

He discovered that a conventional variable transformer, hooked up as a reactor and operated in series with a capacitor, held steady speed on his grinder—regardless of load. Not believing his good luck, and being a chemical engineer with unspecialized knowledge of electricity, he consulted Prof Douglas E. Howes, a motor expert in the Electrical Engineering Dept of nearby Worcester Polytechnic Institute. Neither man has yet been able to convert the demonstrable facts into academic theory, but tests run in Kalenian's home workshop proved the idea was practical—and he went ahead to patent it.

There are at least two dozen available ways to get wide-range variable-speed performance from motors—everything from adjustable pulleys to electronic frequency changers. But for a simple motor-control system that uses an ordinary design electrical motor and has a remotely located single-knob adjustment, the choice has been limited to three systems. Now there is a fourth—the brand-new reactor-capacitor control described here.

As with the three old-timers in the field—rheostat, variable autotransformer, thyratron—this hybrid sets motor speed by varying motor voltage. Here's how they compare.

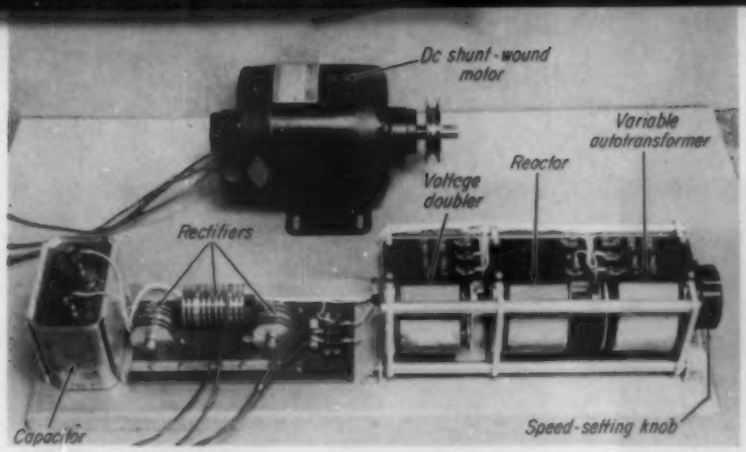
Rheostats are the simplest and have the lowest initial cost. For widest speed range, the rheostat resistance is inserted in series with the motor armature. It controls speed by reducing armature voltage. However, efficiency will be extremely poor at low speeds because of the heat dissipated in the resistance. The best efficiencies are obtained at higher speeds, where the rheostat is set for lower values of resistance. Motor speed will drop about 50% from no load to full load because of the combined effects of voltage drop with current in the resistance, and normal speed drop-off with load in the motor. Applications are normally limited to fractional-hp motors.

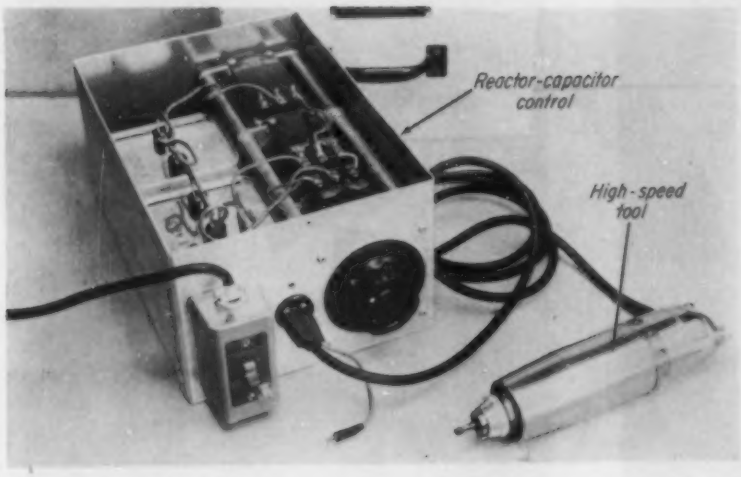
Variable autotransformers, operating from a 120-v 60-cycle ac line, can adjust motor voltage directly. Transformer efficiency is 95-98%, and over-all system efficiency at full load is over 80%. However, the simplest autotransformer controls have no load-compensating circuitry. Motor speed drops from no load to full load will exceed 25% for a shunt-wound, 50% for a series-wound motor. The drop is less, however, than with a rheostat control.

Thyratron (electronic power tube) controllers vary the motor effective voltage (root-mean-square average) by controlling the percent time of each ac cycle that the tubes are transmitting power. Supply voltage—240 or 480 v—is converted to the necessary tube voltages with a transformer. Efficiencies are moderately low—30 to 70%, depending on load—because heat is dissipated in the cathode of each tube. And about 1 to 5 minutes' warmup time is required.

Speed for any given setting stays fairly constant with load, assuming the load is applied gradually. Load-compensating circuits, based on electrical phase-angle relationships, increase voltage across the motor automatically. However, suddenly applied loads will slow down the motor noticeably until the automatic compensation takes effect. For example, at about 10% speed, sudden application of

text continued on page 82



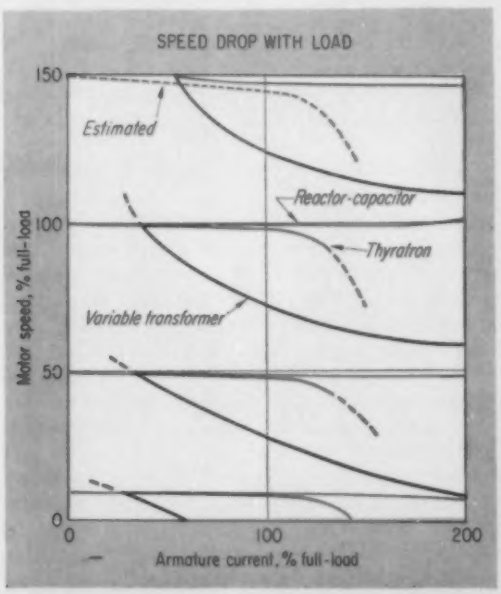


The reactor-capacitor at work

DC SHUNT-WOUND MOTOR (upper photo)—rated at ¼ hp—is driven by the reactor-capacitor control mounted on the breadboard. The variable autotransformer adjusts the input voltage, setting speed. Reactor-capacitor elements vary this input voltage automatically to hold speed constant when load fluctuates. Reactor is a modified autotransformer, has square-loop magnetic-iron core material; voltage doubler steps up voltage across the capacitor, making it possible to use a smaller capacitor. Circuit is shown in schematic C(a), p 83.

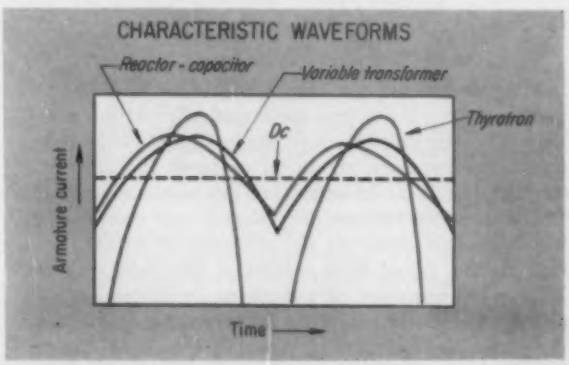
AC-DC SERIES-WOUND MOTOR—rated at ½ hp—is heart of hand-held tool (lower photo). With the reactor-capacitor control shown, speed drop from no-load to full load is limited to about 7% at a set speed of 35,000 rpm, and about 5% at 7500 rpm. With the variable transformer alone (reactor-capacitor not used) the speed drop would exceed 50%. Simplified circuit is shown in schematic A, p 83.

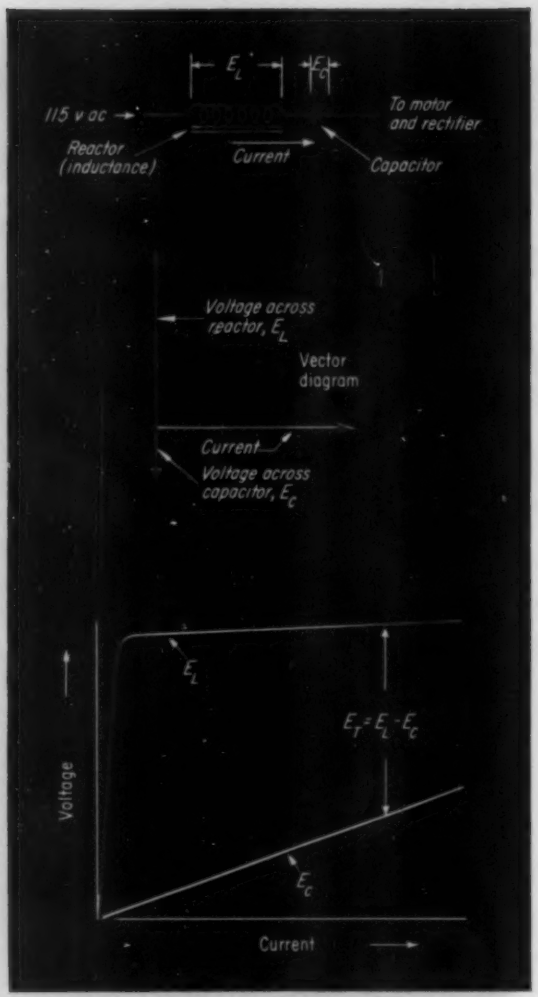
Reactor-capacitor compared with other controls



SPEED REGULATION CURVES (at left) for both thyratron and reactor-capacitor drives show less speed drop with load than an uncompensated autotransformer drive. However, a thyratron drive, if loaded quickly, tends to drop in speed momentarily, takes over 1 or 2 seconds to "recover."

CURRENT WAVEFORMS affect efficiency of a motor (curves below). For ac-dc series-wound and dc shunt-wound motors, a pure straightline dc waveform is the most efficient. Somewhat less efficient are the almost-sinusoidal waveforms of a variable-transformer and reactor-capacitor drive. Least efficient: a broken waveform such as that for a thyratron. Each curve has the same average current, single-phase 60-cycle supply.





SIMPLIFIED VECTOR DIAGRAM in center shows how voltage drop through capacitor is about 180 electrical degrees out of phase with the inductive voltage drop of a reactor. Effective over-all voltage across both in series is inversely proportional to current (bottom diagram) because the increasing capacitor voltage drop actually subtracts from the relatively constant drop through the saturated reactor. Voltage reaching motor consequently increases with current, reducing speed drop with load.

full-load torque will stall the motor for 3 or 4 seconds, before allowing it to regain speed gradually. At full speed, the motor only slows down to one-half speed before recovering. For improved regulation of speed, a tachometer feedback circuit can be added, but this adds complexity.

The new reactor-capacitor control (reactor in series with capacitor) combines the efficiency of an autotransformer drive (about 80% over-all at full load) with the 3-7% speed regulation of a thyratron. Furthermore, sudden applications of torque do not appreciably slow down the motor because response is within ½ cycle of line frequency. The control's basic parts are easy to understand and to service—an electronic engineer is not required. Supply voltage is 240 v, and feeds the speed-controlling variable transformer directly. Curves on preceding page give speed-drop comparisons with the other three systems.

There are other speed-control methods that are as simple, but they do not meet all the basic requirements listed above. For example, an adjustable pulley drive is economical and dependable, but motor and adjustment mechanism are in the same bulky housing. Magnetic-amplifier motor control is compact and versatile, but is most suited to tachometer feedback control—adding complexity.

HOW A REACTOR-CAPACITOR WORKS

The reactor-capacitor control operates from single-phase, 240-v, 60 cycle ac current. It adjusts motor voltage by using a combination of inductance and capacitance to absorb a portion of the system's input voltage. Remainder of the total voltage reaches the motor terminals, supplying the needed power. Very little energy is lost in the control because of the inherent good efficiency of the elements.

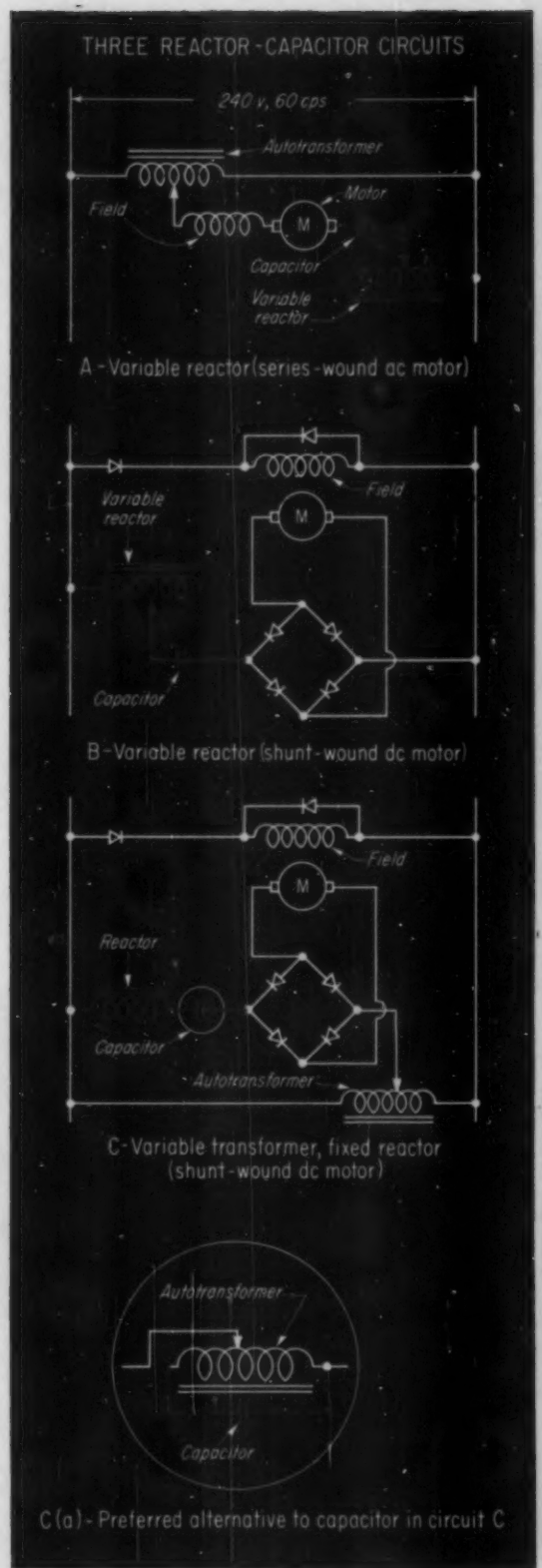
The reactor portion consists of an inductance with magnetic-iron core. The core is made of square-loop material that saturates quickly; the voltage drop through the reactor then stays fairly constant—about 60 to 80 v—despite wide variations in current that will pass through the windings. The core must be saturated to operate, so about 70 v must be applied to it before the motor begins to receive power.

The capacitor—in series with the inductive reactor—passes ac current readily, but has voltage and current peaks approximately 180 electrical deg "out of phase" with those in the reactor. This phenomenon—characteristic of an inductance and capacitance in series—means that a voltage increase across the capacitor will actually subtract from the relatively constant voltage of the saturated reactor.

The capacitor—heavy-duty, oil-filled—will continuously carry the full motor current, including high overloads. To reduce capacitor size, you can use the voltage-doubling transformer that is illustrated on next page in schematic C(a).

To understand reactor-capacitor operation, assume the motor is running at a given speed and load. If the load is increased, more armature current is demanded by the motor. The increased armature current, passing through the reactor-capacitor in series with the motor, produces additional voltage drop across the capacitor, subtracting from the constant voltage across the reactor. Total voltage drop across the reactor-capacitor part of the circuit is then less, and voltage reaching the motor increases. The automatic increase in motor voltage compensates for the normal tendency of the motor to slow down with load, and no tachometer feedback is required.

These fail-safe features are inherent: opening the reactor circuit shuts down the motor; and shorting the capacitor changes over-all phase relationships, reducing power factor to nearly zero and slowing down or stopping motor. Additional features such as remote control, dynamic braking and reversing are possible with the reactor-capacitor control, but more circuitry is required.



THESE BASIC CIRCUITS

Each of the typical circuits shown on this page is practical, but only two—*C* and *C*(a) have major advantages over other ways to control speed.

Circuit *A*—for a series-wound ac-dc motor with a 5:1 speed range—has been tested and proved satisfactory (see photograph on p 81). It counteracts the tendency of a series motor to drop in speed with load. However, for most industrial applications, a shunt-wound dc motor will give better control, over a wider range of speeds.

Circuit *B*—a variable reactor controlling a dc shunt motor is most suitable in the 1/50 to ½-hp range, but not readily adaptable to higher hp motors. It does show the inherent simplicity possible in a reactor-capacitor control.

Circuit *C*—voltage adjusted with a variable transformer instead of a variable reactor—is best. The capacitor and reactor are relatively standard parts. And a dc shunt-wound motor is easier to control than a series motor.

Circuit *C*(a)—a variation of *C*—replaces the simple capacitor with a transformer-capacitor unit. The transformer is variable (approximately 2:1 ratio) and the capacitor is connected across the high-voltage terminals. It solves three problems: reduction of capacitor size; adjustment of effective capacitance to suit motor chosen; and limitation of inrush current.

A smaller capacitor is possible because the transformer steps up the voltage, and increases power capacity in proportion to square of voltage (doubling voltage reduces size by 75%). Voltage can be adjusted to change both capacitance and inductance, allowing exact speed compensation for the motor selected.

Inrush current—the third problem—is automatically limited for across-the-line starting at medium and full-speed settings. This is because the first transient inrush of current (estimated to be well over four times the full-load current) produces a high-voltage drop (approximately 300 v) across the capacitor. This voltage is high enough to instantly saturate the square-loop magnetic-iron core of the transformer. The transformer, in effect, becomes a saturated reactor adding enough inductance to the motor circuit to limit inrush current to 1½ to 2½ times the full-load current. When the motor reaches set speed, the current will drop (assuming motor is not excessively overloaded) and the transformer will unsaturate, letting normal and overload currents from zero to 300% full load flow again. The same limiting action applies if the motor is overloaded excessively, or stalls.

For REPRINT of above article just check P39 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Articles introducing many important new motor and motor-control designs have appeared in these pages:

Spherical-type Variable-speed Motor, July 7 '58, p 68, evaluates British-made skewable-stator ac induction motor.

Printed-circuit Rotors, Mar 16 '59, p 64, shows how to write your own design specifications for a dc motor with a disk-shaped rotor that has plated conductors instead of windings.

Improved Dc Motors, Mar 31 '58, p 108, describes a new watercooled, shell-type field-and-armature controlled design that is very compact.

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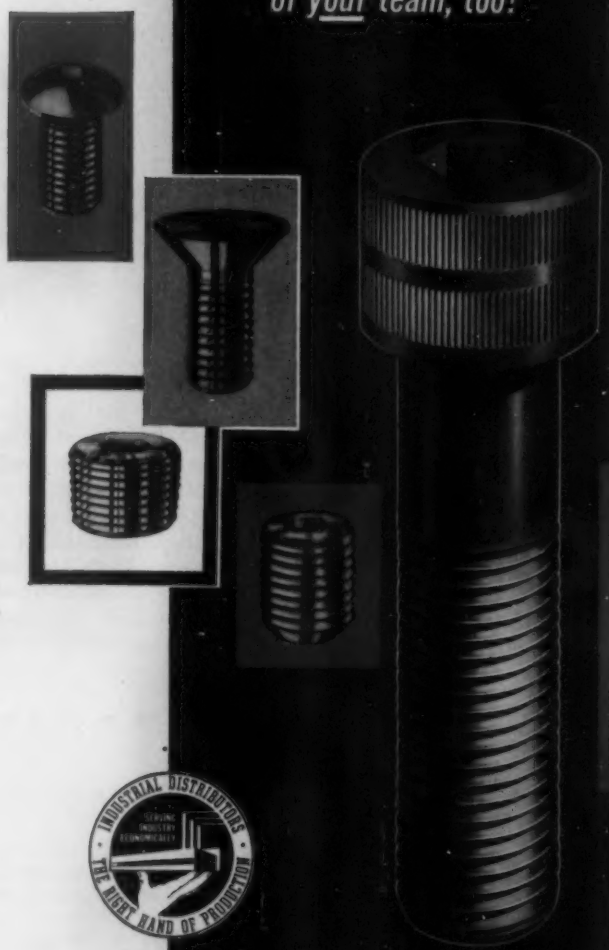

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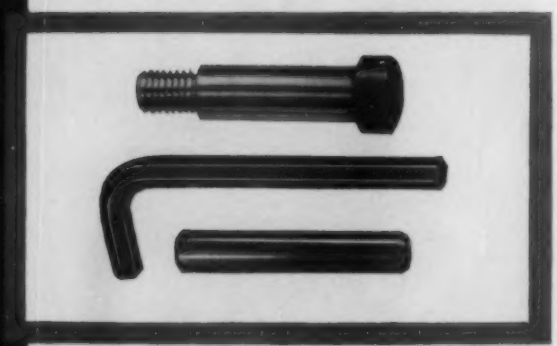

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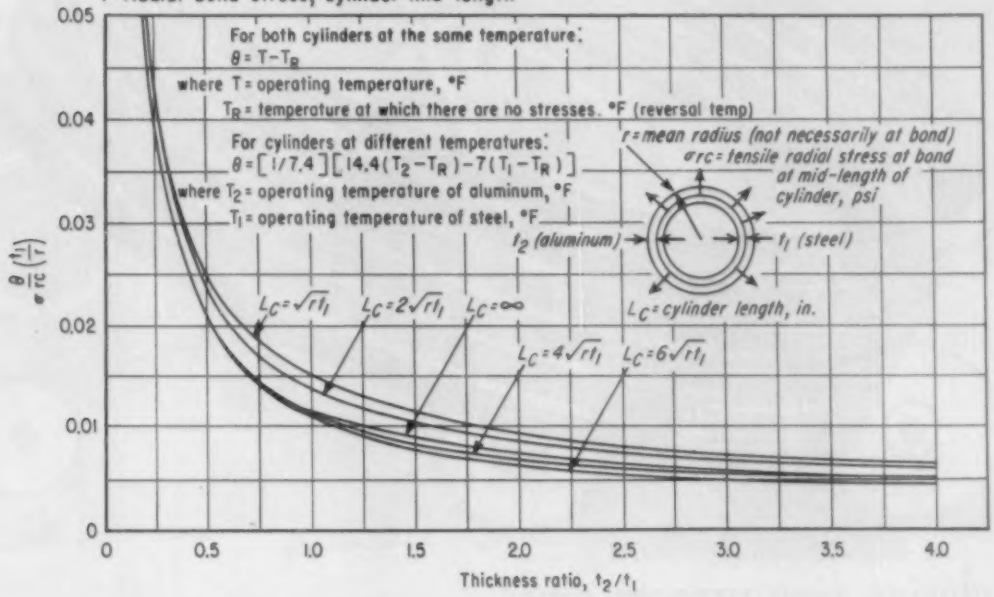
how to find THERMAL STRESSES IN TWO-PLY CYLINDERS

GEORGE T LADD
Ladd & Little Inc, Huntington Station, NY
D M PEARCE, *chief design engineer*
Cleveland Pneumatic Industries, Washington, DC

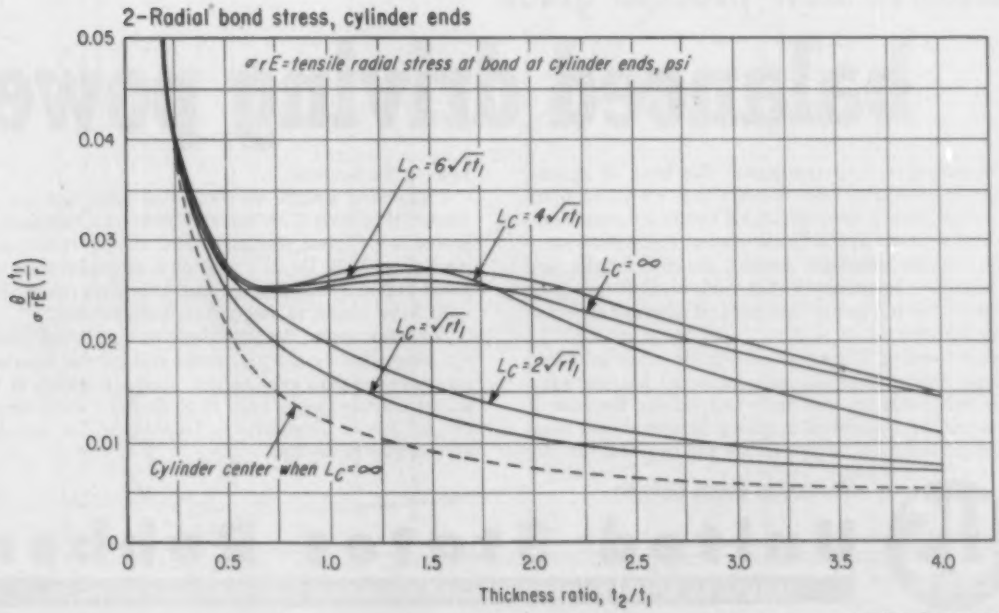
Cylinders of bonded steel and aluminum are finding increasing usefulness in products where strength and wear resistance with maximum heat dissipation are required. Examples are brake drums, heat exchangers and special-purpose pressure vessels.

The curves presented here find what thermal bond-stresses will occur when cylinders of alloy steel and aluminum are firmly bonded together. (Combined thickness must be less than 0.1 times mean radius.)

1–Radial bond stress, cylinder mid-length



2–Radial bond stress, cylinder ends



continued on page 87

U. S. ROYAL V-BELTS from the Power Unlimited complete belt line

Exclusive new process gives

balanced driving power

Now you can give your equipment the kind of driving power that comes only from V-belts that are as close-to-perfect as the world's most advanced manufacturing methods can make them. Specially developed equipment automatically controls thickness, weight, density, length, and tension members so precisely that each U. S. Royal gives you *balanced* driving power that pays off in every aspect of a belt's performance.

Smoother running. Variations inherent in other belts lead to vibration, intermittent slippage, increased bearing wear, excessive heat build-up, and early belt failure. Because of the "balanced driving power" resulting from exclusive manufacturing processes, U. S. Royals are the sweetest running belts in the business.

Unequaled length stability. Test after test has demonstrated that each U. S. Royal V-Belt with balanced driving power is a perfect working match for the others in its set. And every U. S. Royal V-Belt on a multiple drive will *continue* to pull its share of the load long after other "matched" belts have begun to assert their individuality.

No weak spots. Because there are no "weak links," you get longer lasting driving power and greater freedom from maintenance than ever before. Take advantage of the balanced driving power only U. S. Royal V-Belts offer. Your "U. S." Power Transmission Distributor has full stocks to service you promptly.

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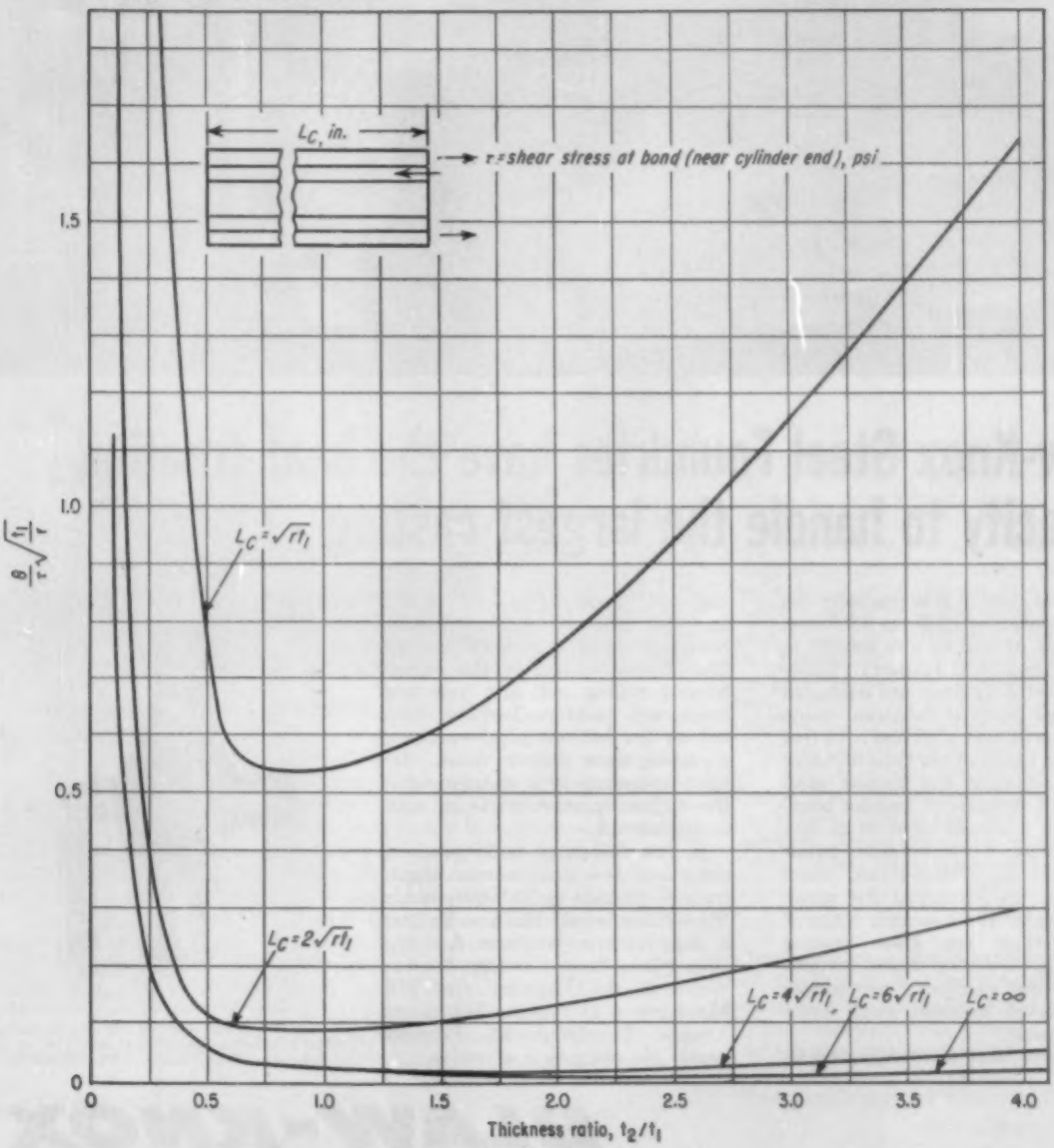
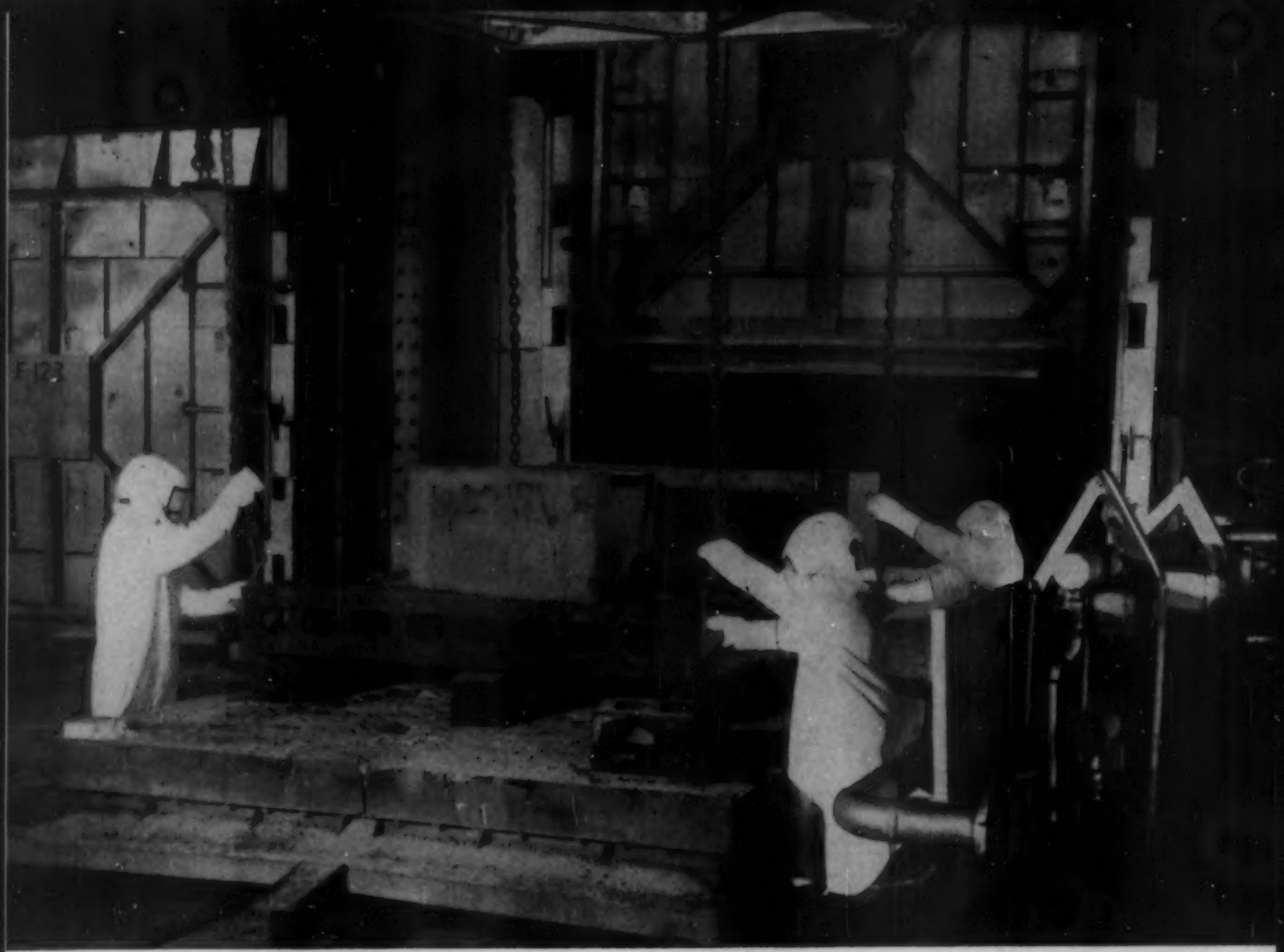
THERMAL STRESSES continued

EXAMPLE: $r = 6$ in., $t_1 = 0.125$ in., temperature difference, $\theta = 600$ F
From charts 1, 2 and 3 for a cylinder 1.73 in. long ($L_c = 2\sqrt{rt_1}$):

When t_2 values are	0.0313	0.0625	0.125	0.250
Radial stress, center	300	535	915	1400
Radial stress, ends	300	475	635	990
Max shear stress	210	615	860	630

3-Axial shear stress at bond





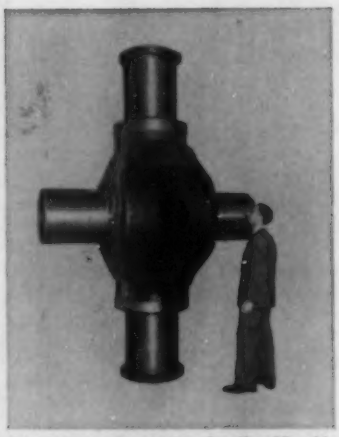
Blaw-Knox Steel Foundries have the heat treating capacity to handle the largest casting

Your steel casting gets precisely the characteristics of uniform hardness, toughness, or temper you specify in a Blaw-Knox Steel Foundry. Blaw-Knox Steel Foundries are equipped with huge pit-type furnaces—some as large as 42 feet × 20 feet × 13 feet deep, and banks of car type furnaces to accommodate the largest steel casting or batches of smaller ones.

Quench tanks as large as 21 feet × 12 feet and 8 feet deep are available, and all Blaw-Knox Steel Foundries are equipped for spray quenching in which specific areas of steel castings are given special quenching. Further flame hardening or other hardening procedures are provided to meet your exact requirements.

Complete heat treating, quenching, and hardening is another way in which Blaw-Knox Steel Casting Service adds value to your product. Blaw-Knox, as one of the world's leading rolling mill and industrial machinery builders, keeps a sharp eye on the end-use requirements of a casting from start to finish. It's your assurance of a component of the highest quality, made for maximum service.

If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania. No obligation of course.



This main axle casting for the 60-cubic yard Mountaineer Shovel was cast in a Blaw-Knox Steel Foundry. Wt.—18,000 lbs.

BLAW-KNOX

Steel Castings

CIRCLE 88 ON READER SERVICE CARD

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES

Heavy-anodizing process produces 13 colors . . . said to be sunfast and atmospherically stable on aluminum sheet (bottom left). Corrosion and abrasion resistance are reported to be equal to those of heaviest present anodic coatings, because coating is 20 to 40% more dense. Available colors include gold, amber, tan, brown, olive, gray and black. Tones result from a reaction of alloying elements within metal. Process is expected to be applicable to forms as well as panels. Now available for license, process is expected to be competitive with present commercial one-hr anodizing. Sheet sizes and gages are standard.

Also available is a process for producing two-color, patterned inlay sheets (upper right). These are laminated of two alloys, embossed with standard Kaiser stucco, diamond, ribbed or square patterns. Raised portions of upper laminate are then removed and sheet polished. Fabricator forms sheet as required, then applies commercial anodizing procedures. End-color combinations include gold, natural aluminum, light gray and dark gray, as shown on cover. Widths up to 36 in.; standard lengths in most standard gages. Prices will depend on alloys and gages. **Kaiser Aluminum & Chemical Corp, 1924 Broadway, Oakland 12, Calif.**

Circle 300 on Reader Service Card

Liquid-spring time delay . . . provides fast-compression spring action with time-delay extension from built-in dashpot. Time delay at end of ¼-in. stroke can be adjusted for up to 42 min. delay for travel of 1/16 in. of return stroke, then release for rapid travel the last 1/16 in. of stroke to actuate other circuitry. Spring force is 8 lb endload; 6 lb preload. Body of spring measures 1 x ¾ in. dia, not including mounting ends. Other models are available with built-in time delay of up to 24 hr or to 2-in. stroke. **Taylor Devices Inc, 188 Main St, N Tonawanda, NY.**

Circle 301 on Reader Service Card

Spray-applied vinyl coatings for use with flat or textured metals are offered in organosol and plastisol vinyl dispersions. Organosols form harder coating than plastisols, but max thickness of single-spray application is usually limited to 6 to 15 mils. Plastisols form more resilient, rubberlike coating and can produce greater single-coat thickness, up to ½ in. Stabilizers and modifiers can be added to either plastisols or organosols (PE—June 28 '59, p 13). In large quantities, plastisols and organosols cost from $5 to $7.50 per gal. Primer is $6 per gal. Standard colors from stock; special colors and lusters, 2 to 4 wk delivery. Test samples are available. **Coatings Div, Metal & Thermit Corp, General Offices, Rahway, NJ.**

Circle 302 on Reader Service Card

Sound waves measure flow . . . of liquid, eliminating flow-restrictive mechanical devices normally located inside pipe. Flowmeter sends ultrasonic beam across stream and measures shift of beam under influence of flowing liquid. Sound from transducer echoes back and forth in-

continued on page 90

side pipe. Because of shift of beam, only a fraction of beam is picked up by sonic detector in opposite wall of pipe. Detector produces small voltage, which can be amplified and read on voltmeter and which varies with velocity of flow in pipeline. Circuits are designed to modify voltage according to density of liquid. Flowmeter is hooked up to remote-control readout devices that show both rate of flow and total flow at any given moment. Devices are packaged in bronze or stainless steel pipe sections, standard diameters, which can be inserted in any pipeline. Can be powered from standard 12-v storage battery or regular 115 v ac. Operates in 40 to 110 F. **Gulton Industries Inc, 212 Durham Ave, Metuchen, NJ.**

Circle 303 on Reader Service Card

Miniature electric heaters . . .

that measure ¾ in. dia x 0.15 in. thick have center hole for mounting to any flat surface. Teflon-insulated lead wires emerge from upper side of heater through special glass-to-metal seals. Heaters are enclosed in metal case, flat on underside for max heat transfer to surface being heated. Operating at 115 v ac or dc, wattage ratings of 2, 5 or 10 w are standard in ¾-in.-dia size. Heater internal temperatures to 500 F are permissible. Temperature-sensitive heater is available for determining internal temperatures to assure heater is operated within its ratings. From stock in quantities to 10 units. Priced at $10 each for 1 or 2 units; $8.50 each for 3 through 10 units. **Minco Products Inc, 740 Washington Ave N, Minneapolis 1.**

Circle 304 on Reader Service Card

Antibacterial polyethylene . . .

is said to kill many types of bacteria and is expected to have major uses in applications where added health protection is important. Available in custom-designed formulations based on polyethylene materials. Development of each self-sanitizing formulation will depend on base polyethylene properties desired. Supplied in granular or pellet form in 5-lb bags or bulk. Reported to carry little or no price premium under present marketing plans. **Dow Chemical Co, Midland, Mich.**

Circle 305 on Reader Service Card

Stainless bleeder valves . . .

permit visual check of bleeding or purging of hydraulic lines while pump or system is in operation. A 360° rotatable discharge port allows directional control of flow. Valves can be used with any high-pressure hydraulic system. For visual check, clear plastic tube may be slipped over discharge nozzle. Available with knurled knob or slotted bleed screw. Burst pressure is said to be above 14,000 psi and valves can be used with all compatible fluids. For temperatures of —65 to 275 F. Three sizes are available with $\frac{7}{16}$-24, $\frac{9}{16}$-24 and $\frac{7}{16}$-20 UNF mounting threads. Mate with AND 10050-2, -3, and -4 ports. **Fluid Regulators Inc, 313 Gillette St, Painesville, Ohio.**

Circle 306 on Reader Service Card

Resonant-reed relay . . .

has four channels with frequencies from 315 to 405 cps. Sensitivity is 3 milliw with bandwidth of 6 cps. Contact rating is 60 milliamp at 67½ v. Field-coil impedance is 27,000 ohm. Unit has closure time of 75 millisec. Measures less than 1¼ in., all dimensions. Price is under $5 in production quantities with immediate delivery. **Bramco Inc, 4501 Belvedere Ave, Detroit 14.**

Circle 307 on Reader Service Card

Speed governor responds to g-force . . .

in domestic appliances. Speed-detector is snap-acting switch designed on virtually frictionless principle. It operates on speed alone, independent of voltage, load or other environmental factors. Tolerances can be held as close as required. Used in washer-dryer combinations, device is attached to driveshaft of appliance in time-delay circuit. During spin-dry sequence, governor cycles about 20 times. When centrifugal force exerted on clothes exceeds 1 g, governor switch cuts out appliance motor, which cause machine to coast and clothes to redistribute. When centrifugal force reduces to less than 1 g, governor switch cuts in motor to start sequence again. Governors are also applicable to automatic-appliance valve sequencing, clutching, blower control, motor protection, speed sequencing through transmission, interconnection of valves, heater coils and similar operating components. **Torq Engineered Products Inc, Bedford, Ohio.**

Circle 308 on Reader Service Card

Close-coupled pump motor . . .

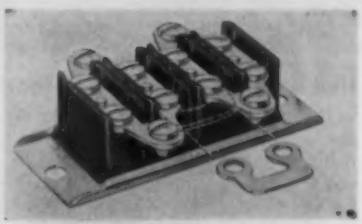
has corrosion-resistant cast iron frame with mounting bracket designed to eliminate mounting base, adaptors and to reduce over-all length of pump-motor package. Enclosed housing is said to protect against exposed couplings. Single- and double-end models are available to fit all standard hydraulic pumps. Ratings are from ¾ to 50 hp. **US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54.**

Circle 309 on Reader Service Card

Perforated sheet . . .

of polyvinyl chloride is said to be suited for contact with long oxidizing chemicals at temperatures up to 168 F; polypropylene is reported to offer good general chemical resistance with exceptional properties in solvent service and suitable for up to 250 F. Both types of sheet are available in 40, 34, 26, 18, 14, 10, 6 and 5 mesh perforated sizes and can be supplied in rolls up to 100 ft long. From stock. **Dorak Products Corp, 78 Pearl St, New York 4.**

Circle 310 on Reader Service Card



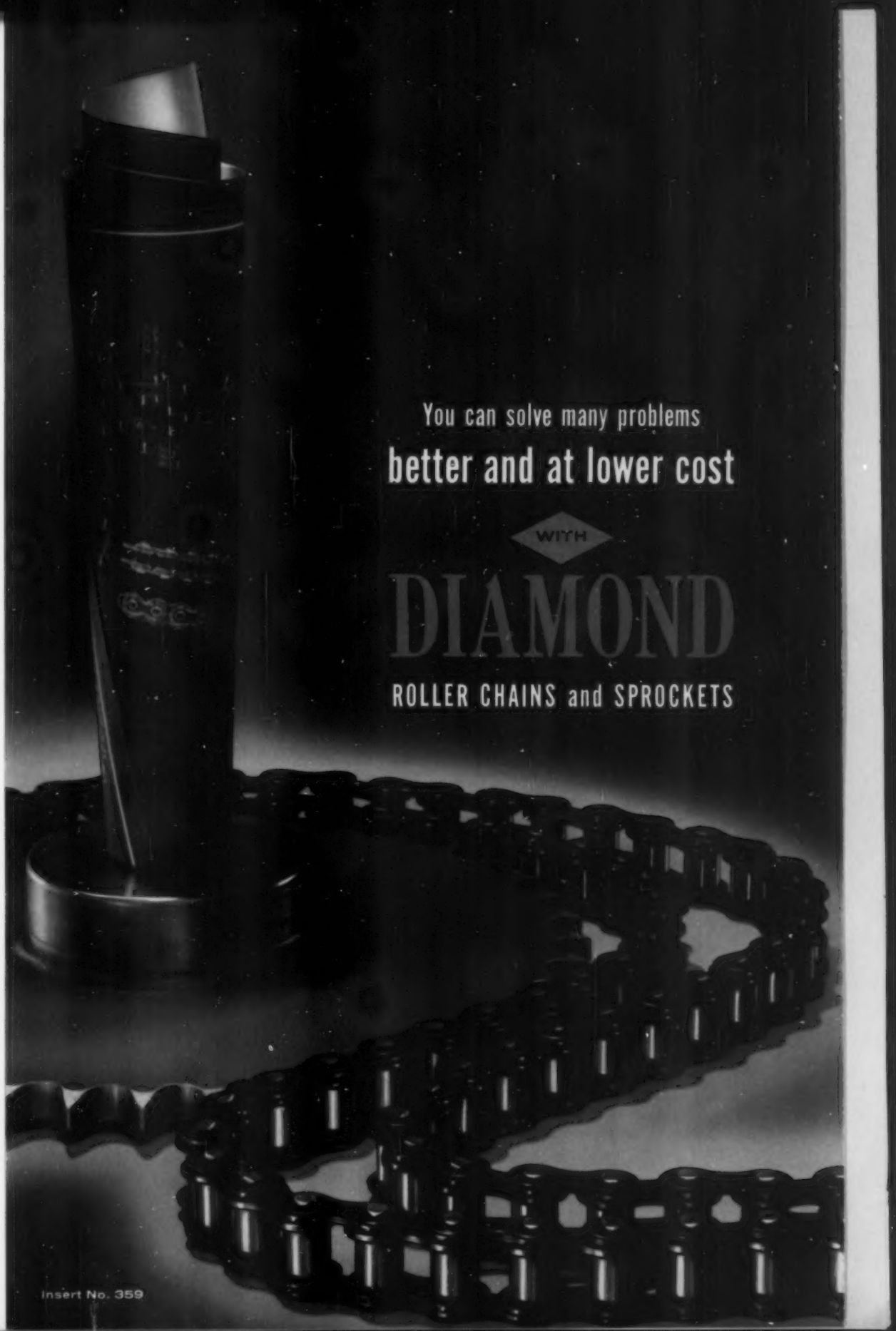
Junction block . . .

provides multiple connections from a single incoming line, through use of jumpers. Handles max total incoming current of 30 amp and is rated at 300 v. Available with from 1 to 12 poles or terminals, jumpers make possible as many as 71 taps for one input. **Curtis Development & Mfg Co, 3250 N 33rd St, Milwaukee 16.**

Circle 311 on Reader Service Card

continued on page 96

CIRCLE 91 ON READER SERVICE CARD→


You can solve many problems
better and at lower cost
WITH
DIAMOND
ROLLER CHAINS and SPROCKETS
Insert No. 359

You get ALL THESE DESIGN ADVANTAGES

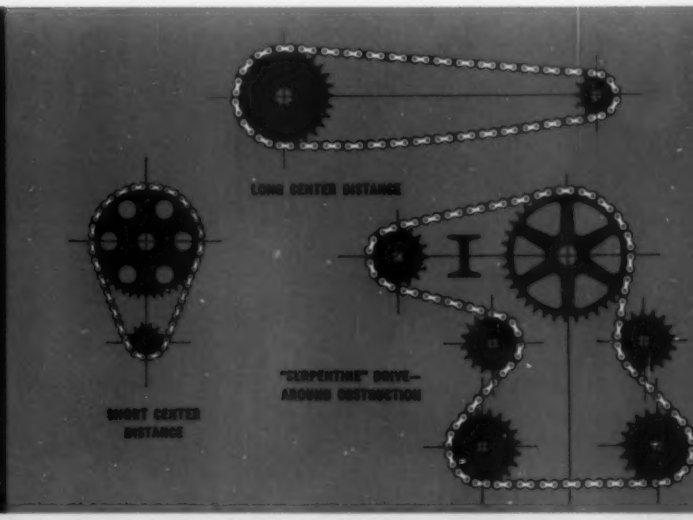
when you use

DIAMOND
ROLLER CHAIN

You get *more for your dollar* with DIAMOND Roller Chain than with any other mechanical power transmission medium. Its important design advantages (some of which are described on these pages) . . . plus low first cost, low installation cost and low service cost . . . make DIAMOND Roller Chain a highly *efficient* and *economical* solution to virtually any mechanical power transmission problem.

Adaptability

DIAMOND offers maximum adjustability to long or short center distances. Several shafts may be engaged, rotated in either direction at various speeds all from a common drive shaft. Speed ratio changes are made easily by changing sprockets.



Positive Power

Multiple engagement of sprocket teeth with roller links assure a non-slipping drive. Heavy static and radial loads, thrusts or bearing pressures are reduced (due to elimination of high operating tension as with belts or separating forces as with gears). DIAMOND standard roller chains cover a wide range of horsepower and speed combinations (see Table).

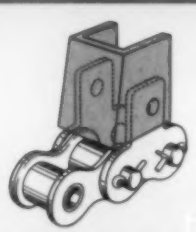
SPEED AND HORSEPOWER CAPACITIES FOR DIAMOND SINGLE AND MULTIPLE STRAND ROLLER CHAINS

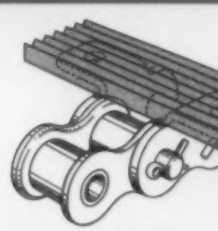
Chain Pitch	Horsepower Up to	At Speeds As High As
¼"	25	8000 R.P.M.
⅜"	120	4500 R.P.M.
½"	220	3370 R.P.M.
⅝"	375	2400 R.P.M.
¾"	480	1800 R.P.M.
1"	950	1160 R.P.M.
1¼"	1440	800 R.P.M.
1½"	1200	650 R.P.M.
1¾"	1540	475 R.P.M.
2"	2300	400 R.P.M.
2½"	2800	280 R.P.M.

For Ratings not shown in table, write to DIAMOND Chain Company.

STANDARD ATTACHMENTS AVAILABLE WITH DIAMOND ROLLER CHAIN

Various types of link plate attachments and extended pins permit the ready adaptation of DIAMOND Roller Chain to a wide range of conveying, timing or synchronized movement problems.

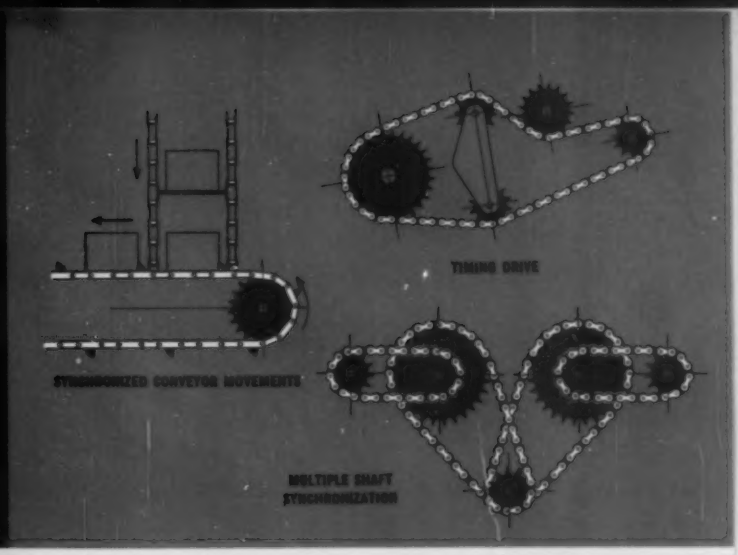




LITHO. IN U.S.A.
COPYRIGHT, 1950, DIAMOND CHAIN CO.

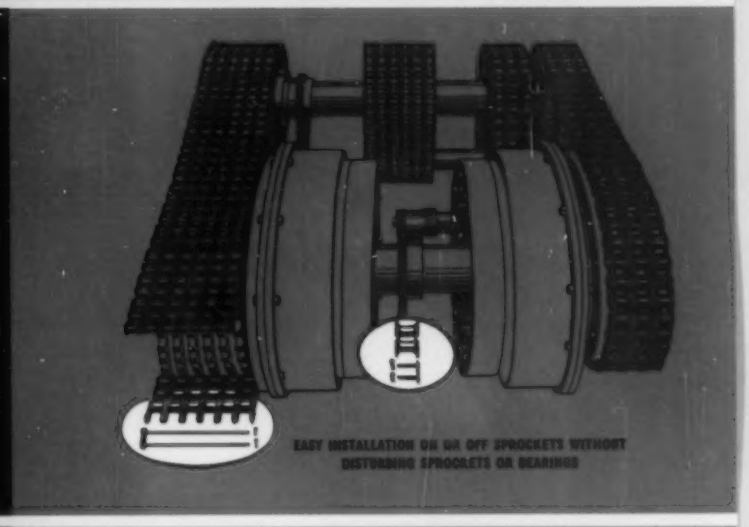
Accuracy

Component parts of DIAMOND Roller Chain are manufactured with uniformity and precision resulting in close total-length chain tolerances. This means that DIAMOND not only operates smoothly and quietly . . . but that two or more chains may be run in parallel or to synchronize multiple shaft movements in one machine.



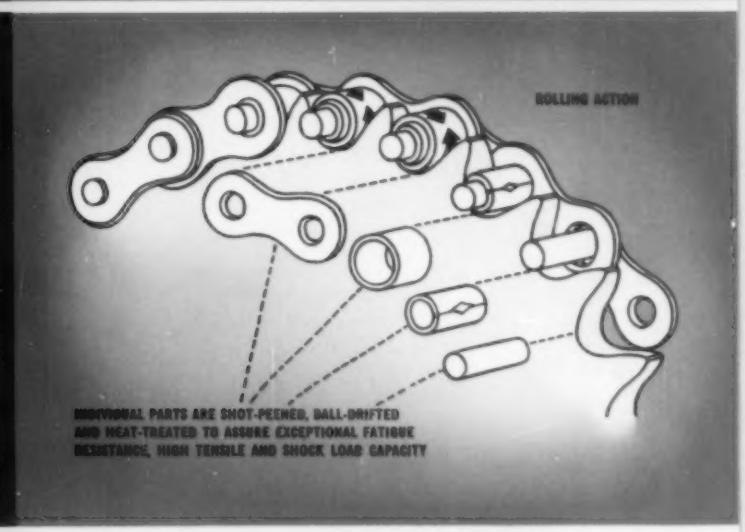
Convenience

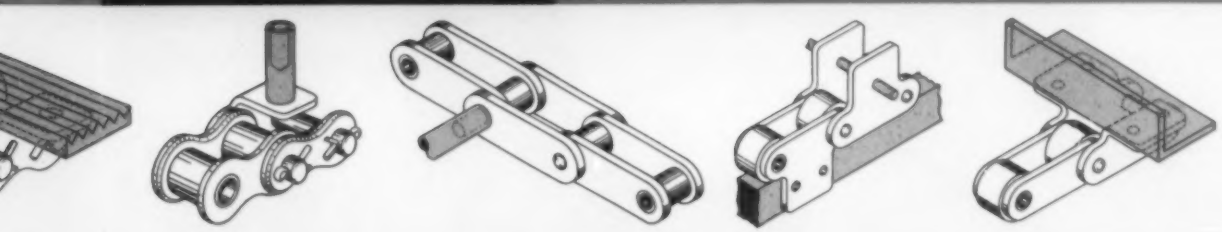
DIAMOND Roller Chain is easily installed. It may be quickly connected or disconnected by means of a connecting link without disturbing sprockets or bearings. Installation does not require precision alignment of sprockets or shafts.



Durability

Manufacturing refinements and strict quality control are responsible for DIAMOND's long life and superior performance. Inherent design—positive engagement, large joint bearing areas, wide distribution of load—makes roller chain 98%-99%* efficient, the highest rating of all mechanized power transmission media.


ROLLING ACTION
INDIVIDUAL PARTS ARE SHOT-PEENED, BALL-DRIFTED AND HEAT-TREATED TO ASSURE EXCEPTIONAL FATIGUE RESISTANCE, HIGH TENSILE AND SHOCK LOAD CAPACITY



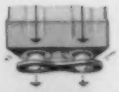
CHAIN CO.

DIAMOND . . . Specialists in Roller Chain Design and Manufacture for more than 68 Years

The quality of DIAMOND Roller Chain . . . both in design and in workmanship . . . is the result of more than 68 years of specialization in solving difficult problems of load, shock, fatigue and abrasion. During this time DIAMOND has contributed many "firsts" to the capabilities of roller chain. It is the *only* roller chain embodying *so many* engineering and manufacturing refinements.

FIRST TO PRE-LOAD PRODUCTION ROLLER CHAIN—Pre-loading seats pins, bushings and linkplates; takes out initial stretch.

FIRST TO STUDY FATIGUE—First to make design changes in roller chain parts for improved fatigue resistance.



FIRST TO BALL DRIFT—Pitch holes in DIAMOND chain sideplates are ball drifted for greater fatigue resistance.
(DIAMOND patent)

FIRST TO EMPLOY SEAM RELIEF BUSHINGS—Seam relief bushings reduce run-in time and provide better lubrication.
(DIAMOND original patent)

FIRST TO PROPERLY PLACE BUSHINGS—DIAMOND bushing seams are placed away from load-bearing area for improved resistance to wear and fatigue.

FIRST TO SHOT PEEN—DIAMOND chain parts . . . rollers, bushings, linkplates and pins . . . are shot peened for greater fatigue resistance.

Diamond Chain Company Representatives

ATLANTA, GEORGIA
82 FOURTEENTH STREET, N.E.

BATTLE CREEK, MICHIGAN
511 MICHIGAN NATIONAL BANK BUILDING

BOSTON, MASSACHUSETTS
945 GREAT PLAIN AVENUE, ROOM 14
P.O. BOX 247, NEEDHAM 92, MASS.

CHICAGO, ILLINOIS
212 SOUTH MARION STREET, OAK PARK, ILL.

CINCINNATI 37, OHIO
7551 HAMILTON AVENUE

CLEVELAND, OHIO
17700 LORAIN AVENUE, CLEVELAND 11, OHIO

DALLAS 5, TEXAS
3301 MOCKINGBIRD LANE

HOUSTON 25, TEXAS
3110 BROOKMEADE

LOS ANGELES 21, CALIFORNIA
909 SANTA FE AVENUE

MINNEAPOLIS, MINNESOTA
215 SIXTH STREET, S.E.

NEW YORK 12, NEW YORK
75 VARICK STREET

PHILADELPHIA, PENNSYLVANIA
401 SUBURBAN SQUARE BUILDING, ARDMORE, PENN.

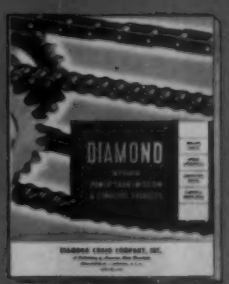
SAN FRANCISCO, CALIFORNIA
805 SANTA CRUZ AVENUE, MENLO PARK, CALIF.

SYRACUSE, NEW YORK
16 HOMER STREET, UNION SPRINGS, N. Y.

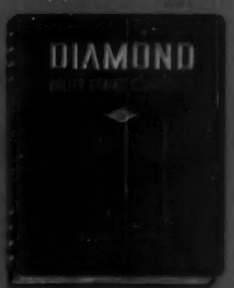
TULSA 14, OKLAHOMA
2230 TERWILLEGER BOULEVARD

Write for DIAMOND Ready-Reference Catalogs Covering All Roller Chain and Sprocket Needs

These DIAMOND catalogs give full description of the subjects listed, including rating, dimension, conversion tables. Also horsepower ratings, service factors and other engineering data to help you select the right chains and sprockets for your equipment.



STOCK ROLLER CHAIN AND SPROCKET CATALOG

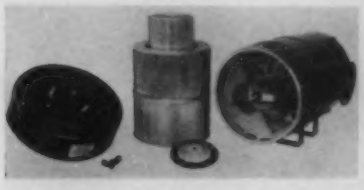


ENGINEERING DATA BOOK FOR DIAMOND ROLLER CHAINS AND SPROCKETS

For complete information or design assistance write direct to:

Diamond Chain Company, Inc.
A Subsidiary of American Steel Foundries
402 KENTUCKY AVENUE
INDIANAPOLIS 7, INDIANA
Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS



Air filters are telescoped . . .
one into the other and independently sealed in housing to provide two-stage air filter for heavy-duty automotive and industrial-engine service. Both elements operate at 99.8% efficiency at all engine speeds. Second-stage element continues engine protection if first-stage, or working element, is damaged. Elements are made from plastic-impregnated cellulose with deep radial pleating. Rated from 450 to 1150 cfm with low initial restriction. Element life is said to be from 600 to 2000 hr continuous use. **Purolator Products Inc, Rahway, NJ.**

Circle 312 on Reader Service Card

Liquid neoprene paint . . .
can be applied by brush or spray to metal, wood, plastic, concrete and other surfaces and dries in minutes to form permanent, protective coating. Permanently flexible, and self-vulcanizing. Impervious to water, oils, gasoline, naphtha, acids, alkalies, and most solvents. Available in pint, quart, 1-gal and 5-gal cans and 55-gal drums. **Adhesive Products Corp, 1660 Boone Ave, New York 60.**

Circle 313 on Reader Service Card

Sampling and measuring . . .
of particles in fluid systems is obtained with photoelectrically actuated counter. Continuous sample is taken automatically and caused to flow past window. As foreign particle passes window, portion of light beam is interrupted, causing change in output signal from photosensitive element that is proportional to size of particle. Signal change is amplified and sent to counter circuits that have been adjusted to various sensitivities. Particle is then tallied according to size. Calibration is obtained with sizing disk. **High Accuracy Products Corp, 149 W First St, Claremont, Calif.**

Circle 314 on Reader Service Card

Adjustable-segment rotary switch . . .
can be externally adjusted to open or close at any point with 0 to 355°. Limited adjustable switches can also be made. Enclosed in standard RR11 servo mount anodized aluminum housing. Ambient

continued on page 98

NEEDED:
VIBRATION ISOLATION
AT BOTH HIGH AND
LOW FREQUENCIES

A mount soft enough to isolate vibration in the upper range of frequencies generally gives trouble with a low natural frequency. With sensitive precision equipment, such as airborne sighting mechanisms, for example, a mount must work at *both* ends of the frequency spectrum.

ANSWER:
MB ISO-DAMP (tm) MOUNTS
CONTROL FULL
FREQUENCY RANGE

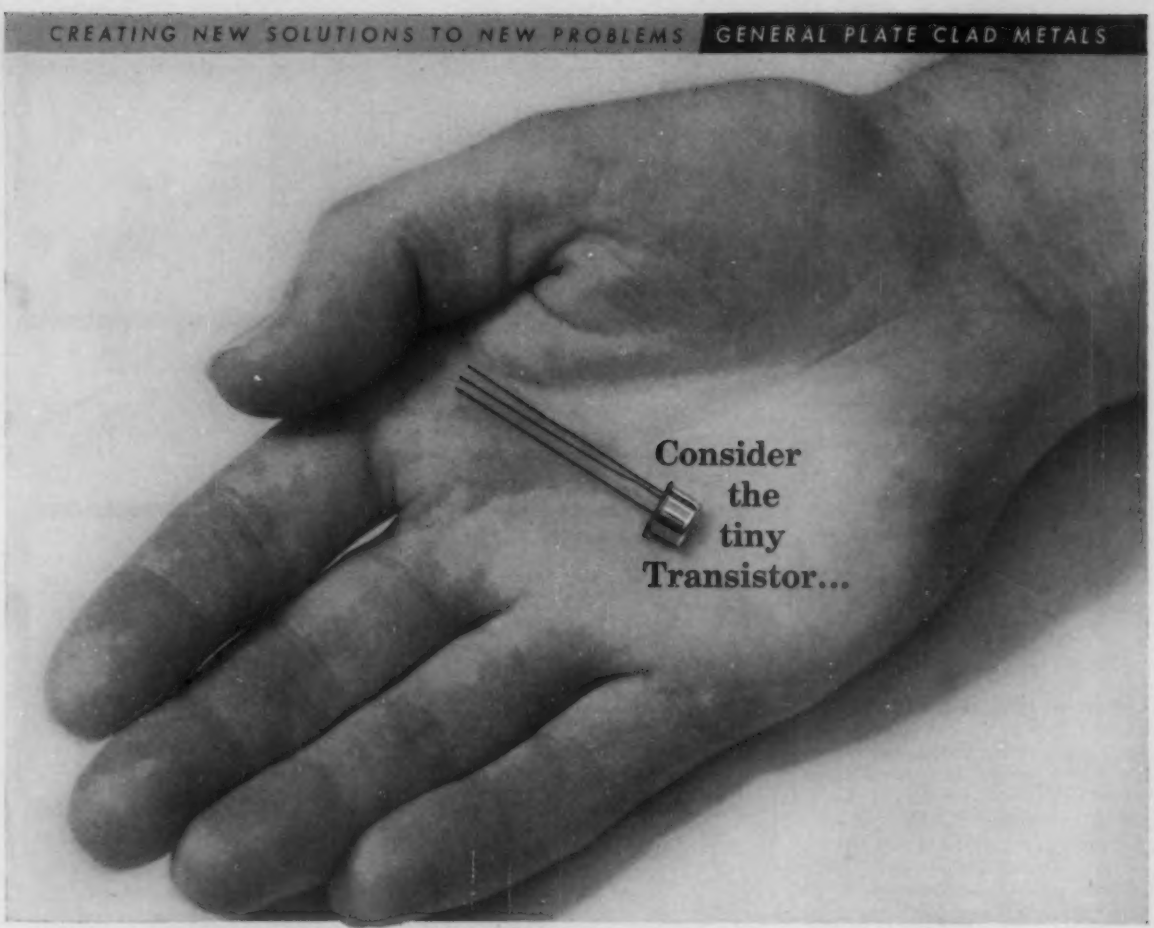
Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give the MB Isomode Mount its high frequency isolation efficiency in any position. In the low range, a unique damping mechanism effectively restricts resonant build-up; does not affect high frequency isolation. Unit also meets MIL-E-5272-A shock requirements.

WHAT'S YOUR
MOUNT PROBLEM?

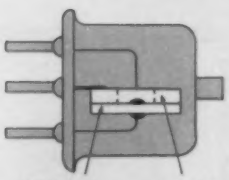
Iso-Damp mounts can be modified to meet your particular requirements. Or possibly one of MB's other standard mounts may be the answer to your special vibration control problem. Why not let MB's experienced specialists help find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1076 State Street, New Haven 11, Conn.

CREATING NEW SOLUTIONS TO NEW PROBLEMS | GENERAL PLATE CLAD METALS



One of a series illustrating how General Plate Clad Metals help uncover new horizons in one of many fields of engineering accomplishments: ELECTRONICS!



Tin clad nickel used as germanium cradle base tab support. The strength of nickel and the solderability of tin combine to solve a variety of physical and mechanical problems.

New Products made with New Materials... New Processes...

USED IN NEW AND DIFFERENT WAYS

Among the important contributions to the success of transistors is the use of General Plate tin clad nickel used as the germanium cradle base tab support. In this one piece of clad metal, the strength of nickel and the solderability of tin were combined to solve a variety of physical and mechanical problems. This made it possible to eliminate expensive hand assembly of minute pieces, or electroplated material that might contain gas or present a porous surface with resulting unsatisfactory performance.

General Plate tin clad nickel is but one of over 400 different combinations of clad metals available which are finding wide use in industry after industry. New combinations are being developed constantly.

No matter what your metal problem, it will pay you to consult with Metals & Controls Division Engineers. Their vast experience in cladding precious to base or base to base metals can overcome your metals engineering problems with multiple property requirements . . . often reduce costs, too. Write for information today.

TEXAS INSTRUMENTS
INCORPORATED
METALS & CONTROLS DIVISION
1003 FOREST STREET • ATTLEBORO, MASS.

GENERAL PLATE PRODUCTS

General Plate Products: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal • Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

Maxitorq 9000 SERIES*

ELECTRIC CLUTCHES or BRAKES

Featuring these

Advantages:

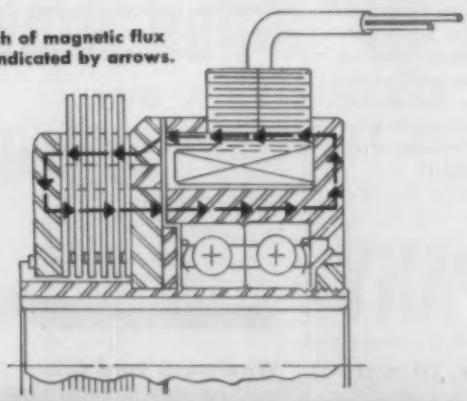
- **Compact and Simple Design**
- **Built to American Standards**
- **Stationary Coil**
- **No Slip Rings or Brushes**
- **Self-Adjusting—Easily Installed**
- **Drag-free Floating Neutral**
- **No Stressed Levers or Parts**
- **Use as Brake or Clutch**
- **Standard Flange Cups Available**

*Patent applied for.

OPERATION INDUCED ENTIRELY BY *Magnetic Flux*

The new Maxitorq #9000 Series Electric Clutch is a compact, self-contained unit with operation dependent upon induced magnetic flux. As shown in the drawing below, this new Maxitorq Clutch consists essentially of a sealed magnetic coil and housing arrangement actuating multiple discs which also act as the flux path. Because the coil housing, supported on anti-friction bearings, is stationary, troublesome brush and slip ring construction is eliminated. When energized, the entire assembly consisting of pressure plate, inner and outer discs, and buttress plate is locked together by the magnetic force passing through it. When de-energized, Maxitorq separator springs instantly separate the discs creating air gaps which help to break up residual magnetism. Compactness, fast response, and flexibility of control make the #9000 Series clutch or brake ideally suited for a wide range of applications.

Path of magnetic flux is indicated by arrows.



Write, phone, or wire Dept. PE now for Bulletin 90 describing the most advanced design of electric clutches or brakes available today.

Let's talk MAXITORQ

THE CARLYLE JOHNSON MACHINE CO. • MANCHESTER, CONN.

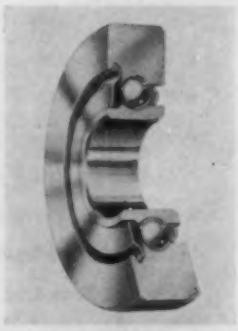
CIRCLE 97 ON READER SERVICE CARD 97

temperature range is —58 to 302 F. Voltage breakdown, 1000 v ac. Life expectancy is to 50 million cycles, depending on current and type of load. Designed to pass MIL environmental requirements. Precision Line Inc, 63 Main St, Maynard, Mass.

Circle 315 on Reader Service Card

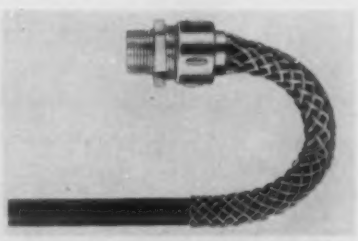
Water-circulation heaters . . . are complete package units consisting of an electric heater with tubular copper sheathed elements, installed in welded-pipe insulated chamber with inlet, outlet and drain. Sizes range from 1½ to 100 kw and for all voltages through 550 v. Three types of thermostats are available. Vulcan Electric Co, 88 Holten St, Danvers, Mass.

Circle 316 on Reader Service Card



Thin-width instrument bearings for use in synchros, gear trains, potentiometers, servos and small motors are said to offer high OD:width ratio. Made to ABEC class-7 tolerances, bearings are available from stock in nine sizes with OD from 0.2750 to 0.5000 in. and bores from 0.0937 to 0.1875 in. Standard material is 440C stainless steel. Open, single and double-shielded bearings are included. Miniature Precision Bearings Inc. Precision Park, Keene, NH.

Circle 317 on Reader Service Card



Wire-mesh cord grip . . . eliminates strain of abrupt transition from flexibility of cable to rigidity of connection. Grip goes from cable flexibility to gradually less flexible connection. Arch of

continued on page 102

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66DD.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

THE TONY ACCETTA "PET" SPOON, made of Revere Brass Strip has been awarded the Medal of Honor by Sportsman's Club of America for superiority of design and fish-getting ability while all Tony Accetta Baits have received National Sportsman's Research Award . . . a real tribute to design, construction and effectiveness.

Revere helps "fit the metal to the job"

AND A BAIT MAKER SAVES ON FORMING AND FINISHING COSTS WHILE PRODUCING AWARD-WINNING LURES

The fishing lures of Tony Accetta & Son, Riviera Beach, Florida, are known all over the world for their ability to catch fish. That's due to design. They are also known for their fine workmanship and ability to take a hammering on rocky reefs and shoals, and still retain their ability to attract fish. That's due to the material from which they are made . . . a Revere Brass with special grain size and finish.

Says the Senior Accetta, "The high quality of Revere Brass has, without a doubt, contributed immeasurably to the quality of our lures. In fact, Revere Brass is of such fine quality and finish, uniform grain size and structure that even after stamping and forming only a minimum of work is required prior to chromium plating. This means we save on both forming and finishing costs. Since we have been using Revere Brass we have not had a single customer complain due to poor quality material."

Why not put the extensive knowledge of Revere's sales representatives to work for you? With the wide variety of metals at their disposal, perhaps they can help you select the metal best suited for the job, with a resultant saving of money while improving product quality.

COPPER • BRASS • REVERE • ALUMINUM

REVERE COPPER AND BRASS INCORPORATED
230 Park Avenue
New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; East Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

CIRCLE 99 ON READER SERVICE CARD

actual size

NEW MINIATURE A.C. MOTOR

high output for commercial use

This a.c. synchronous motor costs you only about half as much as its miniature precision counterpart for military applications. In production quantities it is so economical that you can design it into good quality products that now use induction motors. And because you can put this **bigger** performance motor in **smaller** spaces, it gives you a head start in miniaturizing your design at the same time you improve product quality.

Vital statistics: This Type CMC motor has a starting torque of .7 oz. in. and a continuous duty torque of .7 oz. in. at synchronous speed. It is 1¼" in diameter by 2⅝" long, and weighs 6½ oz. The shaft is precision ground stainless steel, supported by ball bearings. The epoxy-sealed design provides good resistance to normal environmental conditions.

If you have hesitated to design with precision miniature motors in the past, now's your chance!

The Globe motor line includes both a.c. and d.c. models. Globe is pleased to work with you to provide the exact motor you need for your commercial, competitive product. Please write for Bulletin CMC. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, STEPPERS, BLOWERS & FANS MOTORIZED DEVICES

GLOBE

can save you hundreds $$$
for pennies spent

extremely
kind to
threads

easy to apply
...and remove

molded of flexible
Polyethylene

Caplugs

now in stock: over
600 sizes in numerous
styles and colors.

tough enough
to stand the gaff

won't chip,
break, shred
or collapse

snug-fitting closures to meet
almost any need you can name...
get a kit full of samples in
exchange for the coupon below.

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PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of Caplugs,
literature and prices to us,
without obligation.

Name

Title

Firm

Address

City Zone State

bend is controlled so that sharp bends and subsequent ruptures are also eliminated. Gripping action is distributed along substantial length of cable. Available for cables of ¼ to 1⅛ in. OD. **Ralco Mfg Co, 123 N Albany Ave, Chicago 12.**

Circle 318 on Reader Service Card

Digital time indicators . . .

in four- or five-digit models indicate time when pulsed each minute, second, ⅒ or 1/100 sec by suitable impulse transmitter. Have instantaneous mechanical toggle-type zero reset. Also available with electric reset. Four-digit unit measures 1⅜ x 1¼ x 4 1/16 in. Indicators suitable for flush panel mounting. Power requirements are 1.6 w at 24 v dc. Typical max readings for five-digit model are 11 hr, 59 min., 59 sec; and 99 min., 59 sec, 9/10 sec. For four-digit model, 99 min., 59 sec. **Landis & Gyr Inc, 45 W 45th St, New York 36.**

Circle 319 on Reader Service Card

Random remote selector . . .

is homing selector for use where it is impossible or impractical to employ mechanically interlocked pushbuttons or other simple methods for remote-selection problems. Handles max of 12 stations or selections per unit. Electrically operated from console, panel or other grouping of switches, usually pushbuttons, with one switch for each selection. When any pushbutton switch is actuated, selector automatically homes on proper contact on rotary wafer switch, making desired circuit and remaining in that position until unit is actuated again. Operates at about 100 steps per sec at 115 v ac. Supplied for wide variety of ac and dc voltages. **Warco Industries, 6625 Delmar**

Circle 320 on Reader Service Card

Motor-load controller . . .

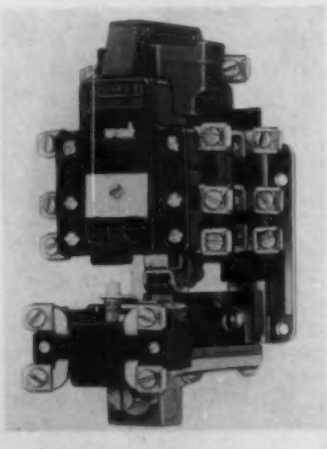
continuously measures real load on drive motor and actuates visible or audible alarm or shuts down machine to prevent damage in case load becomes too great. For use with machines that use ac induction motors for driving power. Instrument will operate with single or three-phase systems at 110, 200 or 440. Senses both voltage and current and measures phase angle between them. Instrument measures real load in kilowatts and indicates measurement in percentage of rated load from zero to any overload percentage. Alarm or shutoff relay can be adjusted to function at desired overload percentage. Costs $195 complete. Available for immediate delivery. **Seneca Falls Machine Co, Seneca Falls, NY.**

Circle 321 on Reader Service Card

Miniature clutch-brake . . .

combination in which both clutch and brake are magnetically set is available in any dc voltage up through 90 v dc. When current is on clutch magnet, clutch will operate and vice versa. When current is turned off both magnets, unit is in neutral position. Has 1.55-amp current rating, 8 in.-lb torque on both clutch and brake side, and comes with bearing-mounted drive and driven shafts. **Stearns Electric Corp, 120 N Broadway, Milwaukee 2.**

Circle 322 on Reader Service Card



Combination relay-timer . . .

combines functions of machine-tool relay with time-delay relay and reduces panel mounting space and installation time that would be required by separate devices. Timer head provides either time delay after energization or time delay after deenergization. Convertible in field from one to other. Timing range is from 0.2 sec to 1 min., ±15%. Available with two normally open and two normally closed or four normally open and two normally closed instantaneous contacts, plus one normally open and one normally closed timed contacts. Relay contacts are rated 10 amp. Pressure wire connectors are supplied on all terminals. **Square D Co, 4041 N Richards St, Milwaukee 12.**

Circle 323 on Reader Service Card

Instant-reversing geared motor

is controlled by built-in adjustable limit switches. Automatic safety device reverses motor rotation whenever predetermined resistant force is encountered by driven product. Ratios of 20:1 through 30:1 are available with worm gear reduction in motor and bell. Electric motors are offered in ⅛- through 1-hp ratings. Designed for use in powering doors, remote valves and similar equipment and for imparting automatic control to indexing, tool operation and other automation requirements. **Franklin Electric Co Inc, Bluffton, Ind.**

Circle 324 on Reader Service Card

Miniature 6PDT, 10-amp relay

is designed as plug-in model, but can be supplied with any type of bracket mounting and header to meet specifications. Six-pole socket is 1 x 1½ in. Switching mechanism is said to be capable of handling 10-amp loads for 100,000 operations. Coil resistances are available to match any transistor or vacuum tube load. Meets requirements of MIL-R-25018, MIL-R-6106C and MIL-E-5272. **Relay Div, Electronic Specialty Co, 5121 San Fernando Rd, Los Angeles 39.**

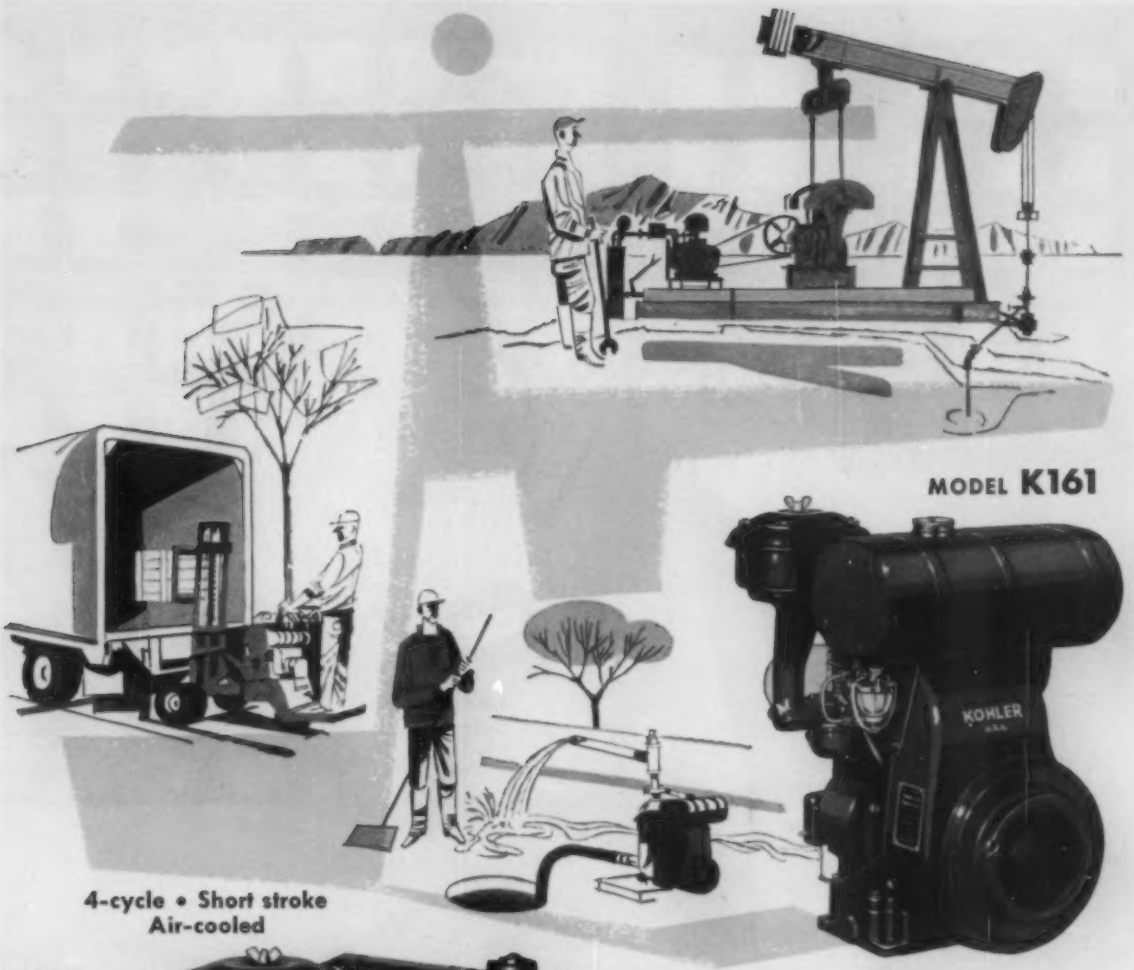
Circle 325 on Reader Service Card

Dished lock washer . . .

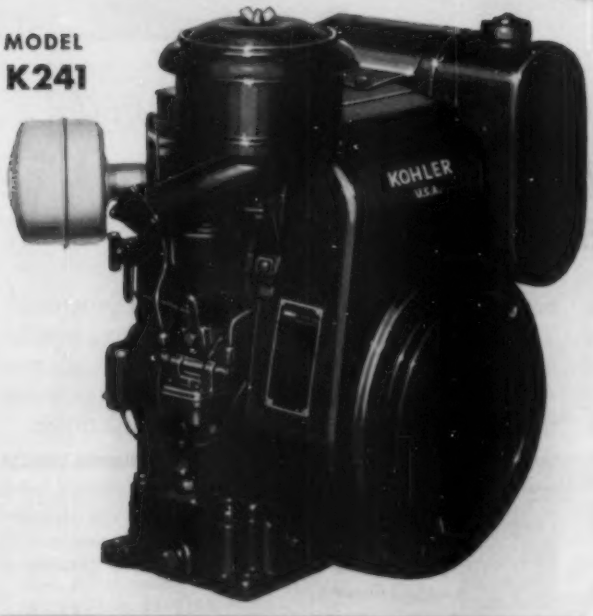
has smooth, burr-free flat rim to prevent scoring of surfaces. This feature is said to be combined with locking action of toothed lock washer and spring takeup of cone washer. Spring takeup compensates for large differentials in expansion between plastics or die-cast materials and steel in screw. Washer can be made in sizes small enough to fit in small recesses in confined areas sometimes found in electrical equipment and related fields. Part can be furnished as free washer. In most cases, washer can replace flat washer now used with split ring washer. **Shakeproof Div, Illinois Tool Works, St Charles Rd, Elgin, Ill.**

Circle 326 on Reader Service Card

continued on page 106



MODEL
K241



KOHLER ENGINES

Reliable power for quality equipment

Kohler Co. has manufactured internal combustion engines for 40 years.

Kohler engines are rugged, quick-starting, conservatively rated.

Short stroke design gives maximum usable power, cuts engine friction.

Nation-wide sales and service.

Kohler engines power Kohler electric plants, known everywhere for reliability.

FROM 4 TO 24 H.P. ***Write for illustrated booklet.***
KOHLER Co. ***Established 1873*** **KOHLER, WIS.**

KOHLER OF KOHLER

ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES • ALL-BRASS FITTINGS • ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION CONTROLS

CIRCLE 103 ON READER SERVICE CARD 103

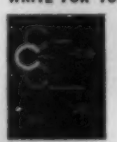
Whatever kind of timing control you need, Cramer is most likely to have it

. . . IN 43 LOCAL DISTRIBUTOR STOCKS

For sheer variety of time-control devices, the Cramer line is unmatched. So, next time you're faced with a problem of accurate timing control, remember that Cramer most likely has the answer already in stock. Usually you'll find that your local Cramer distributor can take it right off the shelf. And in exceptional cases, he can get it from the factory in a matter of hours.

Every Cramer product is the result of advanced design and rigid quality control in manufacture. Over the years, each type has been developed to meet exacting requirements, as industry's needs progressed. Today, the "classics" among them are giving trouble-free performance in countless applications all over the world, while models of more recent design neatly handle jobs that hadn't been thought of a year ago.

WRITE FOR YOUR COPY OF THE 18-PAGE CRAMER DISTRIBUTOR CATALOG



. . . full of facts and figures on standard stock units. And if your problem needs a non-standard solution, let Cramer engineers help you with it. You'll find they have most of the answers at their finger tips.

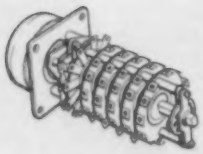
ELECTROMECHANICAL DIVISION

CRAMER CONTROLS CORPORATION

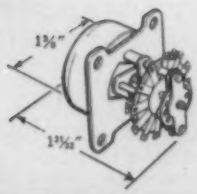
CENTERBROOK, CONNECTICUT

Ledex Rotary Selector Switch

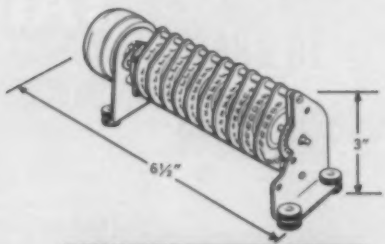
BASIC INFORMATION



Functions as a power operated remote control circuit selector or stepping switch



Smallest switch is size 2E with 1 to 4 switch wafers.



Largest standard switch is size 3S with 1 to 16 switch wafers, test, flange or panel mounting.

8 position 24 position

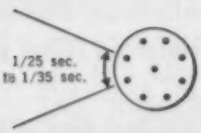
Switch wafers available with 8, 10, 12, 18, 20 or 24 positions.

1 circuit, 12 positions

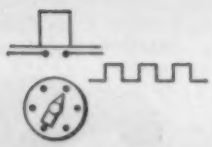
3 circuits, 4 positions each

Circuitry of wafers is flexible. For example 12 position wafer can be one circuit with 12 positions or 3 circuits with 4 positions each.

Will self-step to any pre-selected position.



Self-stepping speed is 25 to 35 steps per second depending on number of positions.



Pushbutton, manual rotary switch, or pulse controlled.

Hermetically sealed switches meet extreme environmental conditions.

The Ledex Rotary Selector Switch is a compact, highly efficient power-operated circuit selector or stepping switch, designed for remote control. Nearly unlimited design combinations permit great variety of applications for stepping, counting, adding, subtracting, programming and sequencing. Many stock models on hand for immediate shipment. Hermetically sealed models also available.

Power source is the Ledex Rotary Solenoid. This unit gives highest-torque-to-size rotary motion. Applications for Rotary Solenoids include actuation of valves, vanes, shafts, and other mechanical loads.

Also Ledex Syncramental Stepping Motors for accurate, reliable shaft indexing.

Write for literature, mentioning application, to Ledex, Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.

LEDEX

CIRCLE 105 ON READER SERVICE CARD 105

Discharge Valve

SWITCH FROM SAND CASTINGS TO BRASS FORGED PARTS

Here's why! Your component parts forged of Titan brass will outperform any you now buy as sand castings. No more costly rejects due to blow holes and sand inclusions. Eliminate leakage and other product failures. The twice-wrought metal in brass forgings has the inner toughness and density to give you new strength and workability. Thinner sections can be used.

Tensile strength is almost double that of most sand castings. Closer tolerances, dimensional uniformity of production lots, and superior finish unknown in sand castings are routine in Titan forgings. For you this means faster chucking and better machinability—threads can often be chased on the forging without preliminary forming. And you have less scrap and less finishing cost prior to plating.

In a Titan forged part you get greater eye appeal to help sell your product. Look at the smooth surface of these forgings to see what we mean; each was once a rough sand-cast part.

May we say more? Call your nearest Titan office for detailed information and a brass forging quote on your sand-cast parts.

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DIVISION OF CERRO DE PASCO CORPORATION

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45 Years of Quality Brass

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Conduit Coupling

Main Valve Control

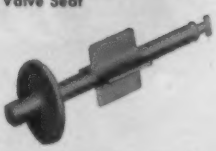
Heat Exchanger Head

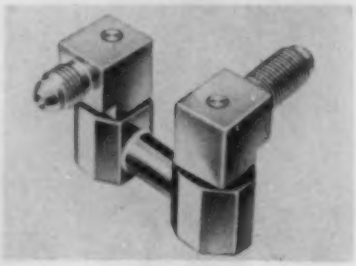
Gauge Socket

Air Compressor Part

Storm Door Handle

Main Valve Seat


Lavatory Pop-up Plug



Swiveling connectors . . .

for hydraulic circuit lines are ballbearing equipped and are said to have low rotating-torque values under full operating pressure due to balanced pressure feature incorporated in design. Available in most materials, may be obtained in single or multiple swivels. Twin-mounted swivel, for example, made of stainless steel, weighs 9 oz. Bulkhead mounted to allow for misalignment of connecting lines. Operates from 0 to 3000 psi, with proof at 4500 psi and burst at 7500 psi. Temperature range is −65 to 275 F. **Airaterra, 620 Paula Ave, Glendale 1, Calif.**

Circle 327 on Reader Service Card

Sumpless torque converters . . .

for vehicles with power-shift transmissions, are single-stage units furnished with input torque capacities of 350, 450 and 650 ft-lb. Standard PTO point is normally used as power implement pump drive; second PTO point, furnished on 350-ft-lb units, is lower-capacity drive to be used for steering pump on vehicles requiring power steering. Available in two capacity sizes, depending on cooling requirements. **Twin Disc Clutch Co, Hydraulic Div, Rockford, Ill.**

Circle 328 on Reader Service Card

Reinforced Teflon gasketing . . .

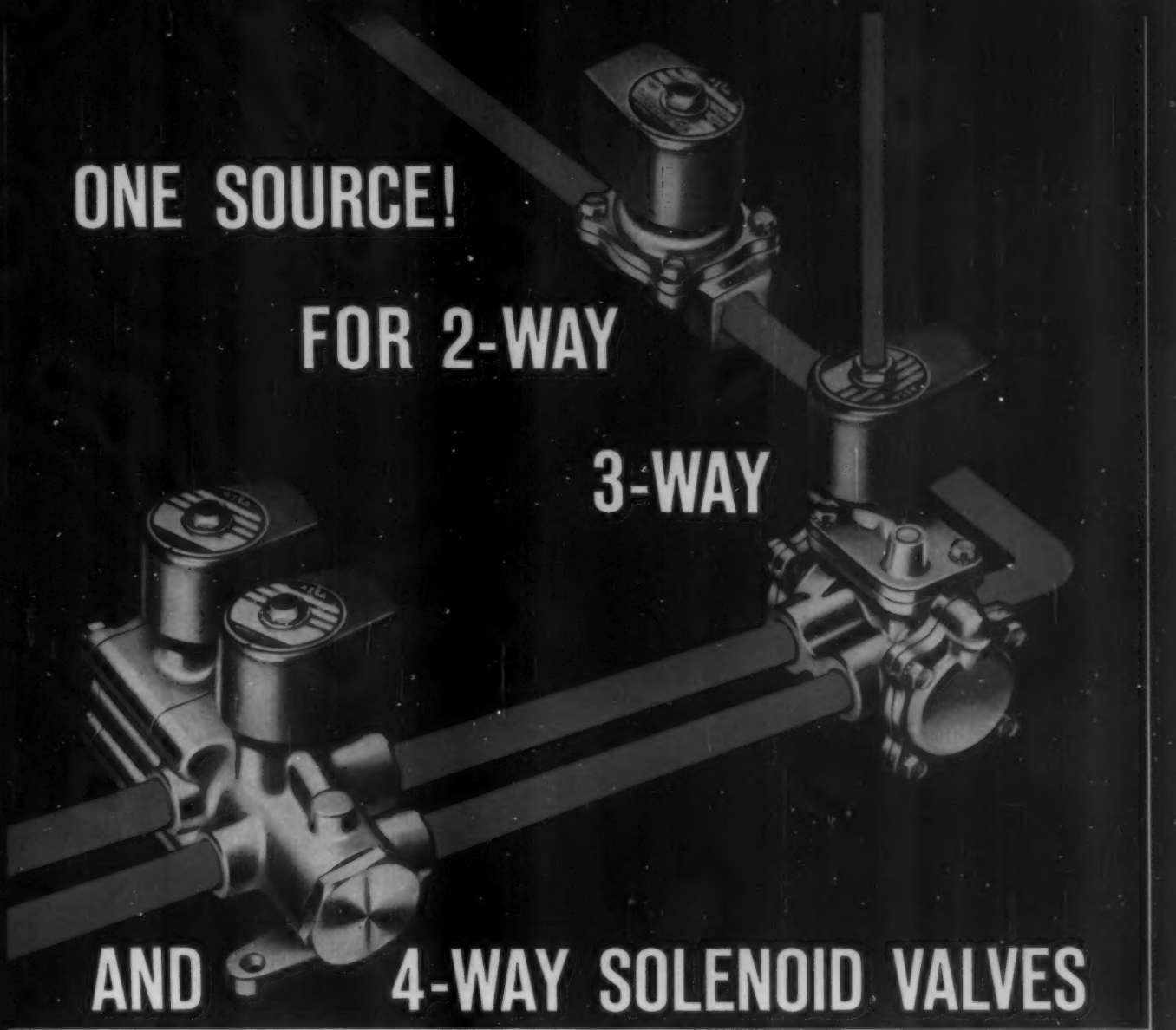
available in sheet form up to 30 x 60 in. and in standard $\frac{1}{8}$-, $\frac{1}{16}$-, $\frac{3}{32}$-, $\frac{1}{32}$- and $\frac{1}{64}$-in. thicknesses is said to be especially suited where light weight is a factor. One sq yd of $\frac{3}{32}$ in. material weighs 30 oz. Synthetic fiber-reinforced nitrile rubber gasket material is reported to have min tensile strength of 1000 psi, resistance to oil and aromatic fuels, good flexibility and non-adhesive and noncorrosive properties. Has 84 lb per cu ft density. **American Felt Co, 2 Glenville Rd, Glenville, Conn.**

Circle 329 on Reader Service Card

Integral-hp ac-dc motors . . .

are for mobile field equipment for use where either ac or dc supply may be encountered. Available in ratings through 7½ hp in 1800 and 1200 rpm speeds.

continued on page 108



ONE SOURCE!

FOR 2-WAY

3-WAY

AND 4-WAY SOLENOID VALVES

When you discuss solenoid valve requirements with an ASCO engineer, you benefit from the design and development experience of half a century. The ASCO specialist can recommend the right valve for your needs because ASCO pioneering has brought about the thousands of types of solenoid valves now available:

Two-way valves in pipe sizes from ⅛" to 8"—for temperatures from -350°F to 600°F—for pressures to 5000 p.s.i.

Three-way valves in pipe sizes from ⅛" to 2"—for temperatures from -350°F to 600°F—for pressures to 1000 p.s.i.

Four-way valves in pipe sizes from ¼" to 1½"—for temperatures from -65°F to 212°F—for pressures to 750 p.s.i.—poppet or slide type.

And ASCO can supply you with standard, explosion-proof or water tight enclosures—Class A and Class H coils—a wide range of body materials including cast iron, brass, bronze and stainless steel. Or trade on ASCO experience and have one of our engineers call.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery...

World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

Whatever the crucial factor in your flow control applications—reliability, compactness, high cycling rate—there is an ASCO valve that meets your need.

ASCO Valves

ASCO

Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 107 ON READER SERVICE CARD

ROTARY AIR
GAST
PRODUCTS

Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

Provide oil-free air with OIL-LESS

GAST rotary vane AIR PUMPS

Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.

Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-V Benton Harbor, Michigan.

*Standard oil-lubricated models also available.

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Standard open ventilated motors are packaged with four silicon rectifiers in bridge circuit that does not require reconnecting for each type of current. Disregarding voltage drop in rectifiers, 115 v dc passes through bridge circuit to motor terminals without change, regardless of polarity. When ac is used, bridge circuit provides full-wave rectification for pulsating dc operation and 115 v ac would drop to 103 v at terminals. Overload protection is provided. **Industrial Motor Div, Robbins & Myers Inc, Springfield, Ohio.**

Circle 330 on Reader Service Card

Fluoride-containing resin . . .

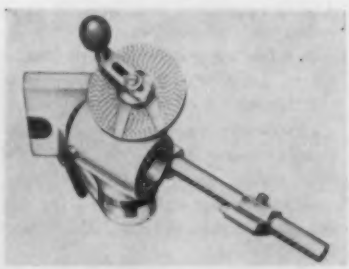
can be fabricated into intricate shapes, sheets, rods and tubes by compression molding, injection molding and extrusion. Dispersions of the resin can be applied by spray-coating and casting techniques to form thin protective coatings over metals and fabrics. Laminates to wood, metal, and other plastics. Resin is a crystalline, high-molecular-weight polymer of vinylidene fluoride. Contains over 59% fluorine by weight. While not yet available commercially, resin is being produced in sizable pilot plant. **Pennsalt Chemical Corp, 3 Penn Center, Philadelphia 2.**

Circle 331 on Reader Service Card

Heavy-duty differentials . . .

in precision ballbearings and oilless bearings are available from stock. Price ranges from $45 to $75, depending upon style and type. Units are balanced with interchangeable and spur clamp rings, which permit user to change end gears upon demand. **Pic Design Corp, 477 Atlantic Ave, E Rockaway, NY.**

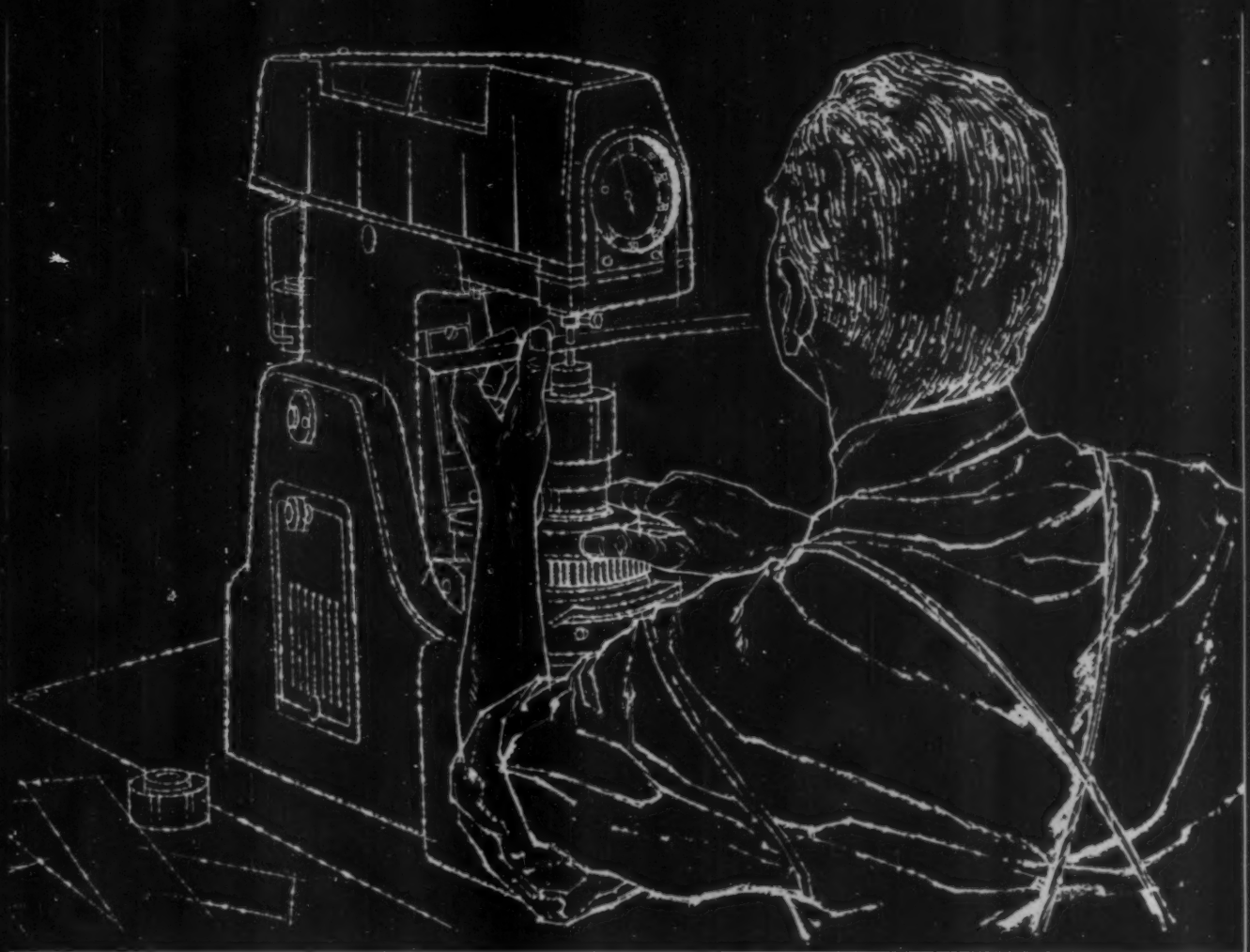
Circle 332 on Reader Service Card



Dividing head . . .

for use in instrument and model shops to produce small precision parts. Spindle has 1 in. capacity with 5 C collets, concentricity within 0.0002, 360° swing in vertical plane and indexing accuracy of 1 min. of arc. Spindle locks in taper section. Uses outboard center to support slender work at any angle. Ball-thrust

continued on page 110



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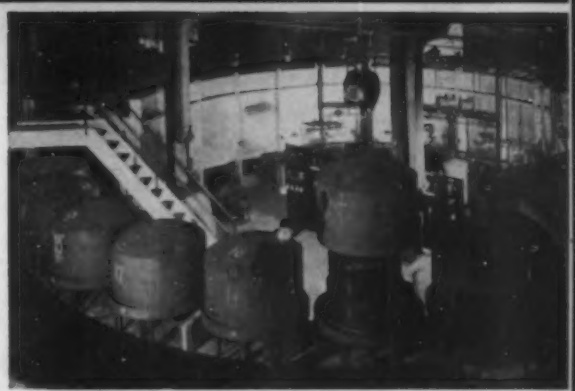
At J&L the newest equipment and techniques are used to provide controlled hardness—to your specifications.

Basic oxygen furnaces, high standard open hearth practice and electric furnaces provide optimum melting conditions, new hot strip mills are specifically designed to produce the finishing temperatures needed for inherent quality. Cold mills, annealing and normalizing furnaces and other equipment are designed specifically for precision strip steel processing.

With an organization experienced in specialized strip steel processing, your most rigid specifications can be met consistently.

For your convenience, precision strip facilities are available to you in our plants at Youngstown, Indianapolis, Los Angeles and Kenilworth (N. J.)



The small unit rotary annealing method assures precision temperature control and develops optimum hardness and microstructure for high carbon, low carbon and alloy strip.

J&L STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

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If you need precision in small metal parts you can get it from Torrington – plus exactly the right finish, temper and hardness required for your needs. Moreover, Torrington can produce such parts at high speed and a remarkably economical cost. We are the leading specialist in this field – with the specialized skills, engineering experience and facilities to save you money. If you have small parts to be manufactured in large quantities why not let Torrington solve your entire problem. Use the coupon below to get prompt action.

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Name_____ Title_____

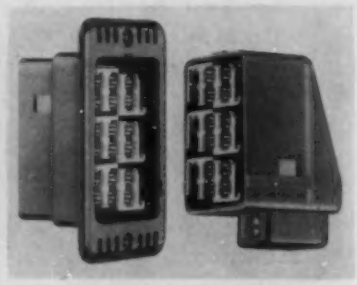
Company_____

Address_____

City_____ Zone____ State_____

bearing drawnut is said to give max chucking force. Falcon Machine & Tool Co, 209 Concord Turnpike, Cambridge, Mass.

Circle 333 on Reader Service Card



Hermaphrodite plug design . . . offers contacts and insulators that fit both plugs and receptacles. Snap-in, crimp-type contacts facilitate assembly and maintenance. Especially suited to commercial applications such as business machines, computers and communications equipment. Variety of layouts is possible within each shell style. Cannon Electric Co, 3208 Humboldt St, Los Angeles 31.

Circle 334 on Reader Service Card

Universal-lug terminal strips replace three popular terminal strips. The 0.205-in. width is suitable male for junior size, quick-disconnect female; inside slot is provided for tie-point terminations; side notches are provided for wrap-solder terminations. Where tie-point or wrap-solder method is used, notch at end of terminal holds first wire when dressed back. Each subsequent wire locates itself. Mandex Mfg Co Inc, Dept PE-1, 2614 W 48th St, Chicago 32.

Circle 335 on Reader Service Card

9- and 16-tube files . . . for large drawings or project plans accommodate material up to 42 in. Rear openings are closed to prevent air circulation. Nine-tube unit has tubes with 4½ in. dia; 16-tube model has tubes with 3½ in. dia. Tubes are encased in reinforced corrugated board container. Visual index record form is furnished with each unit. Roll and File Systems Inc, PO Box 3863, Detroit 5.

Circle 336 on Reader Service Card

Rubber graph stamp . . . produces 3-in.-sq graph pattern wherever necessary. Eliminates need for attaching separate sheets of graph paper to written material. Graph pattern is 100 blocks per sq in. Priced at $3 postpaid. Edmund Scientific Co, Barrington, NJ.

Circle 337 on Reader Service Card

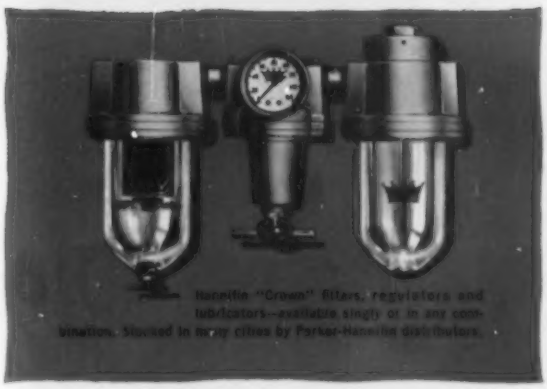
Circle 111 for Hannifin, 204 for Fittings & Hose→

Hannifin air power cylinders, available in a full range of mounting styles, bore sizes from 1½" through 14", strokes to 20 feet. Cylinder bodies bored, then honed satin-smooth . . . for low friction, long packing life.

PARKER-HANNIFIN
puts air to work without costly leaks

Now . . . complete pneumatic power systems, engineered for long leak-proof life, are available from your Parker-Hannifin man. Hannifin "Crown" units supply filtered, lubricated air at optimum pressure. Hannifin air valves shift quickly and seal bubble-tight. Hannifin air cylinders and air motors are low-friction, leak-proof. Parker "Push-lok" hose fittings and "Intru-lok" tube fittings provide quick, easy, leak-proof connections. The over-all result is more work from less air!

Our field engineering service helps you design your circuits and select the components. Many items are available locally, from Parker-Hannifin distributor stocks.



Hannifin "Crown" filters, regulators and lubricators—available singly or in any combination. Stocked in many cities by Parker-Hannifin distributors.

The Hannifin air motor combines a high-efficiency, leak-proof power cylinder and its directional control valve with built-in speed controls into one compact package. A single air line connection is needed, reducing installation costs.

A bench-backed hand push joins Parker "Push-lok" hose fittings to Parker hose. No tools required. Won't blow off.

Parker "Intru-lok"® tube fittings are for low and medium pressure lines in copper, aluminum, nylon or polyethylene. You simply insert the tube end and tighten the nut. No-leak, vibration-proof grip.

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
555 S. Wolf Road, Des Plaines, Illinois

NOW—A Great New Combination for DOUBLE PROTECTION Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life protection from handling, and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.

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DESIGN LITERATURE

Theory of Mechanical Vibration

KIN N TONG, John Wiley & Sons Inc, 440 Fourth Avenue, New York 16. 6 x 9, 348 pp. $9.75.

This book offers a broad treatment of the theory of linear mechanical vibrations, using modern analytical concepts and techniques. It has been written to correspond with modern curricula which emphasize analytic principles over practical details.

The book demonstrates the unity and coherence of the theory and its connection with other engineering sciences. Topics receiving special consideration are: principle of superposition, eigenvalue problem in matrix, differential and integral equations and energy methods. The author gives systematic and logical developments of all the important theorems and results, from the simple to the complex.

Computers and People

JOHN A POSTLEY. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5¾ x 8, 241 pp. $6.

Subtitle: Business Activity in the New World of Data Processing.

To the engineer, a computer is a design tool or a control device but the area where computers have had most widespread impact is the field of business mechanization and data processing. This book explains what modern computers can mean to businessmen, managers and other nontechnical people. Here is a discussion of the economics of computers and the compromises a data-processing specialist must make on behalf of the organization he serves. Future equipment and capabilities of computers are predicted and the social problems created by data-processing equipment are discussed. Included is an illustrative review of some present and forthcoming applications.

Aircraft & Missiles

D M DESOUTTER. John de Graff Inc, 31 East 10th St, New York 3. 9 x 11, 213 pp. $7.50.

Intended for the general reader, this book has been kept as simple as possible, but will prove rewarding to anyone who seriously wants an understanding of the field. This well illustrated volume covers the fields of aircraft and rocketry in all its branches. Starting with a chapter describing the characteristics of air, the book goes through sections on flight, propulsion systems, aircraft structures, specialized aircraft, guided missiles, history of flight, and ends with records and a glossary of terms. The inclusion of much technical detail and many drawings make it an excellent reference volume for the field.

Mathematics Dictionary

Edited by JAMES and JAMES. D Van Nostrand Co Inc, 120 Alexander St, Princeton, NJ. 6 x 9, 546 pp. $15.

Although this is a fairly comprehensive dictionary, its great value lies in its appendices—an interlingual glossary, table of mathematical functions, differentiation and integration formulae. The definitions themselves are highly technical and not always clear; but, in general, they are accurate; and the book would be a valuable addition to any engineering library.

Guide to the Space Age

C W BESSERER and H C BESSERER. Prentice-Hall Inc, Englewood Cliffs, NJ. 7 x 9½, 320 pp. $7.95.

Compendium of terms used in space technology, and associated fields of rocketry and guided missiles. Terms are defined in layman's language and arranged in alphabetical order. A cross-referencing system is used to guide the user to the exact nomenclature and position of standard scientific terms. Illustrative drawings are used wherever possible to clarify descriptions and concepts.

Automating the Manufacturing Process

GEORGE F HAWLEL. Reinhold Publishing Corp, 430 Park Ave, New York 22. 6 x 9, 147 pp. $4.95.

An automatic machine that performs a complex production task is really an assembly of simple machines —a composite of many clever and ingenious ideas. The basic concepts of how to integrate these functions into a practical, working machine are covered in this book. It is not a design guide or reference work but presentation of the fundamental ideas behind

continued on page 115

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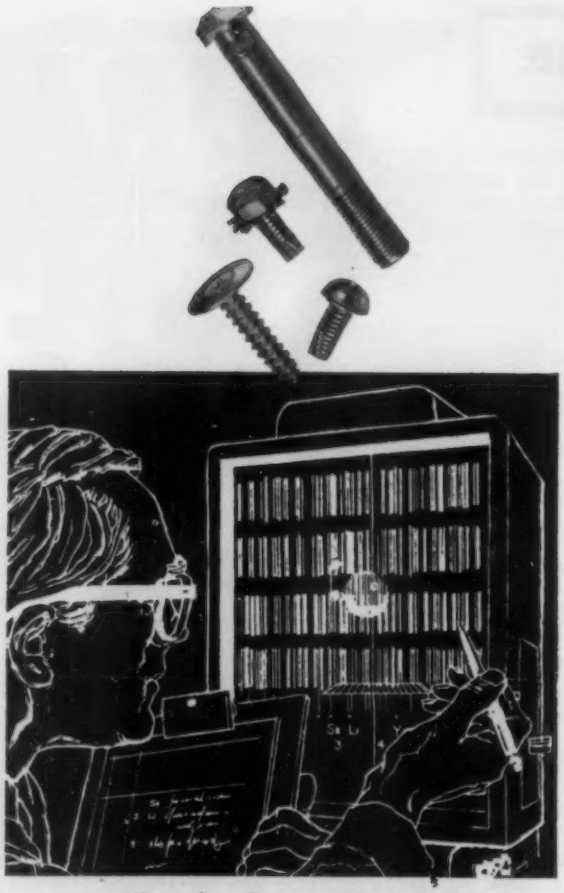

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the development of any automatic machine. Separate chapters discuss such topics as: economic feasibility, getting started, invention, building a model, design, debugging, run-in.

Financial Aspects of Producing and Buying Printed Circuits

Prepared by Institute of Printed Circuits Inc, 27 E Monroe St, Chicago 3. 8½ x 11, 44 p. $5.

What factors boost printed-circuit costs? How can you specify for highest reliability and best performance? Proceedings of a conference called by the Institute of Printed Circuits to answer these and related questions are now available in mimeographed form. The booklet is expensive; but for those concerned with cost and "make or buy" decisions, it's worth reading.

Friction and Wear

ROBERT DAVIES, Elsevier Publishing Co, Spuistraat 110-112, Amsterdam-C, Netherlands. 7 x 9½, 191 pp. $5.50.

Increased reliability and life, expected from engines and other mechanical devices, makes it imperative to have closer control over the wear and friction of the components. Fortunately, the present activity in solid-state physics in general, and in surface-state physics and chemistry in particular, has greatly increased our knowledge of friction and wear during the past few years.

We are obtaining a steadily improving picture of the basic physical and chemical processes that the cause wear and that determine friction. At the symposium, international leaders of research on friction and wear discussed their latest work and thoughts. These complete proceedings of a symposium organized by General Motors Research Laboratories at Detroit in 1957 (full title: "Proceedings of Symposium on Friction and Wear"), cover the whole gamut from current experimental to theoretical research.

Other Books of Interest

Study Abroad

UNESCO Publications Center, 801 3rd Ave, New York 22. 6 x 9½, 755 pp. $3.

International handbook of fellowships, scholarships and educational exchange. Volume XI, 1959-60.

Transient Response of Double-fluid Heat Exchangers

151905. Arpaci, Redlien, Clark. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 92 pp. $2.25.

American Standard Pellet Sizes

MH1.1-1959. ASME, 29 W 39th St, New York 18. 8½ x 11, 20 pp. $2.

An Electrolytic Saw

PB 151574. M Metzger. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 8 pp. 50¢.

Describes a metal-wire cathode system for rapid strain-free cutting of crystals in the laboratory.

Physical and Mechanical Properties of Nine Commercial Precipation-hardenable Stainless Steels

PB 151068. Roberts, Roach & Hall. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 83 pp. $2.25.

Dictionary of Atomic Terminology

Philosophical Library Inc, 15 E 40th St, New York 16. 5½ x 8½, 298 pp. $6.

AFS Buyers Directory 1959-1961

American Foundrymen's Society, Golf & Wolf Rds, Des Plaines, Ill. 8¼ x 11½, 329 pp. $10.

The Education of American Businessmen

Frank C Pierson & others. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6¼ x 9¼, 740 pp. $7.50.

A study of university-college programs in business administration. One of the books in the Carnegie series in American education.

The Chemical Industry Facts Book

Manufacturing Chemists' Assn, Inc, 1825 Connecticut Ave, NW, Washington 9, DC. 6 x 9, 163 pp. $1.25.

Fourth edition, 1960-61. Reflects latest information on what the industry is, what it does, and what it makes.

Principles of Optics

Max Born and Emil Wolf. Pergamon Press Inc, 122 E 55th St, New York 22. 6½ x 10, 803 pp. $17.50.

Thermoelectric Properties of the Noble Metals and Their Alloys

AEC-tr-3724. Aleksandr Alekseevich Rudnitskii. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 234 pp. $2.50.

Vision in Military Aviation

PB 151653. Wulfeck, Weisz & Raben. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 378 pp. $5.

Materials in Space Environment

151900. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 366 pp. $4.

Proceedings of the Fifth Sagamore Ordnance Materials Research Conference.

Chemical Process Principles: Part II, Thermodynamics

Hougen, Watson, Ragatz. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9¼, 1072 pp. $9.75.

American Standard High-speed Steel and Cast Nonferrous Single-Point Tools and Tool Holders

B5.29-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 8 pp. $1.

ABSTRACTS FROM THE LITERATURE

Fastener Standards

Each of the organizations that issues standards for general-purpose fasteners is discussed, and its method of operation described. In addition, each of the types of standards prepared by the various groups included are listed and described. Standards of the American Standards Assn, ASTM, US Government, SAE and the Industrial Fasteners Institute are presented.

"Here's the Score in Fastener Standards." Fasteners, Vol 1, No 4. Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.

Testing Materials at Low Temperatures

Techniques developed for evaluating the mechanical properties of materials at temperatures between −423 and −452 F are described. Included are hardness, impact, tensile, fatigue, torsion tests and strain measurement, conducted both in liquid hydrogen and cold helium gas.

"Notes on Mechanical Testing Techniques at Very Low Temperatures." Defense Metals Information Center Memorandum 43. Battelle Memorial Institute, Columbus 1, Ohio.

Open-gear Lubrication

Open gearing, such as is found in rotary kilns, cranes and shovels, draglines, chain and sprocket drives, and the problems of providing proper lubrication of this type of exposed equipment are described. Included are discussions of the relationship between

continued on page 117

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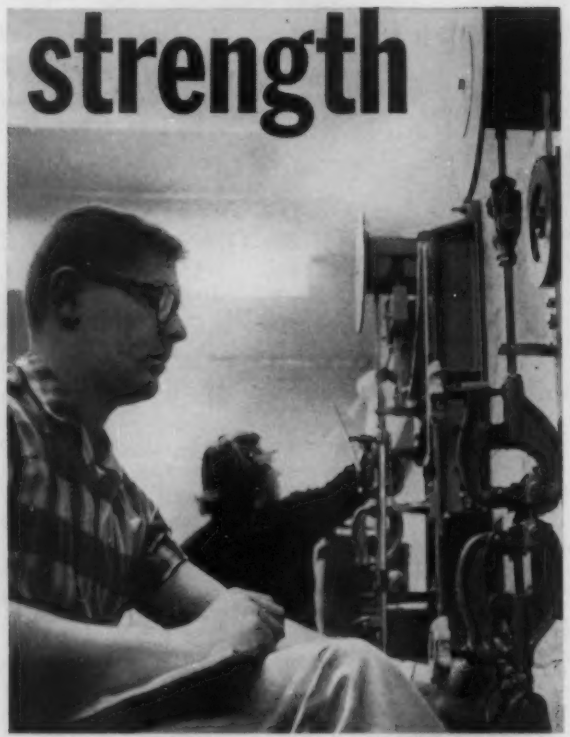

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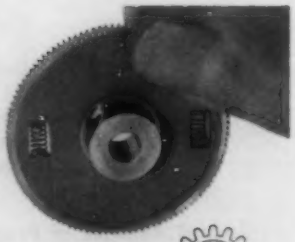

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composition and performance of lubricants, development of laboratory methods to evaluate improved lubricants, and comments on field performance of new lubricants.

"A Study of Open-gear Lubrication," Daniels and Malloy, Esso Standard Oil Co. NLGI Spokesman, Feb '60. National Lubricating Grease Institute, 4638 J. C. Nichols Parkway, Kansas City 12, Mo.

Information on Magnetostriction

59 pages of abstracts from technical literature on the subject, from 1900 to 1959.

"Informative Abstracts on Magnetostriction in Cobalt and Cobalt Alloys," Ellis Fletcher, Battelle Memorial Institute. Cobalt Infomation Center, 505 King Ave, Columbus 1, Ohio.

Systems Analysis

Discusses systems and systems analysis from three standpoints: historical (from Newton and Laplace to the present), philosophical (describes parallel between learning process and the systems viewpoint) and practical (specific examples of systems are presented).

"Constructs, Models and Systems," Quackenbos and Butterworth, General Motors Corp. SAE paper 113C. SAE, 485 Lexington Ave, New York 17.

Parameters for Compression-spring Design

Presents a system of parameters to enable the engineer to portray graphically the complex variables involved in the design of springs for specific sets of operating conditions. Derivations are based on number of coils as well as OD, which is represented as

continued on page 119

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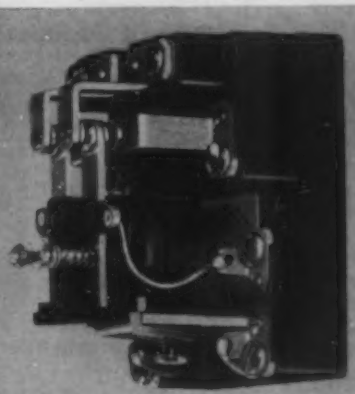

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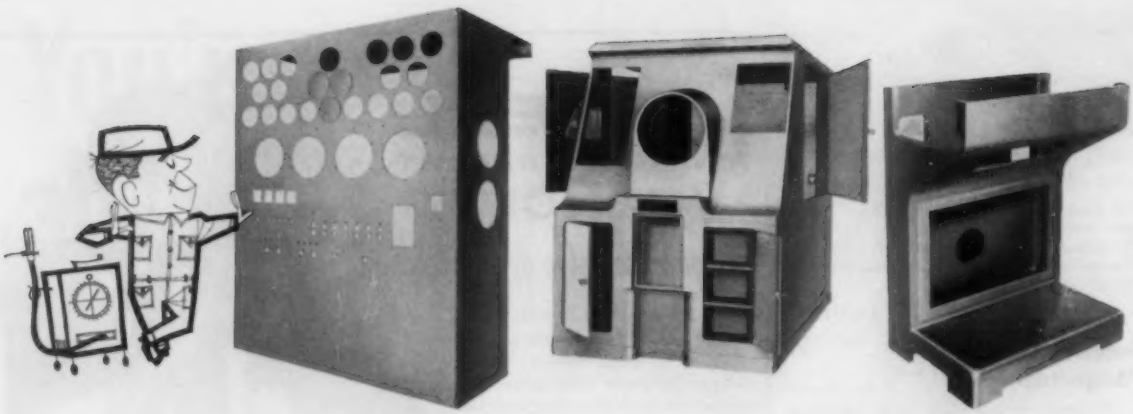

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accurately defining the entire space required for the spring. Charts are included for springs with two dead coils and a torsion modulus of 11,500,000 psi.

"Dimensionless Parameters for Helical Compression Springs," R. J. Erisman, International Harvester Co; ASME paper 59-A-30. ASME, 29 W 39th St, New York 18.

Applying Ultrasonics During Casting

Experiments are described in which grain refinement was achieved in large cast structures by ultrasonic vibration during solidification.

"Uses of Ultrasonics on Grain Growth During Casting," D. H. Lane, Westinghouse Materials Laboratories, Pittsburgh.

Influence of Surface Properties on Corrosion Resistance

In an effort to determine reason for difference in corrosion resistance of steel sheet used for automotive body panels, steel chemistry was analyzed, hardness measured, surface condition checked. Although investigation did not rule out other factors, substantial evidence was developed that lead contamination was an important cause.

"Influence of Variations in the Surface Properties of Steel on the Corrosion Resistance of Body Panels," Gene L. Leithauser, General Motors Research Laboratories, SAE paper 134A. SAE, 485 Lexington Ave, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

COATINGS FOR VACUUM METALIZING—Booklet, 45 pp. Describes application and use of vacuum metalizing coatings. Discusses base coats, as well as top coats and back-up coats. Bee Chemical Co, Logo Div, 12933 S Stony Island Ave, Chicago 33.

Circle 350 on Reader Service Card

DISK-TYPE THERMISTORS—Brochure, 60 pp. Section I discusses thermistor terminology, characteristics and thermistor applications. Includes chart of preferred disk-type thermistors. Keystone Carbon Co, Thermistor Div, St Marys, Penna.

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ELECTRIC MOTORS—Stock list brochure 108-60, 28 pp. Lists hundreds of

continued on page 121

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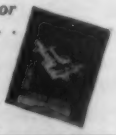

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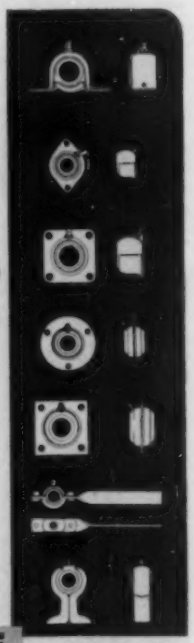

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STAINLESS STEEL SMALL TUBING—Catalog 10, 12 pp. Basic guide to selection and use of stainless steel tubing from 33-gage hypodermic needle sizes to tubing of up to ½ in. OD. With tables of property data, sizes, tolerance and weight information for all commonly used shapes and sizes. Posen & Kline Tube Co Inc, Box 549, Norristown, Penna.

Circle 354 on Reader Service Card

HIGH-TEMP EPOXY NOVOLAC RESIN—Bulletin, 30 pp. Describes properties, formulation, end uses and handling procedures for Epoxy Novoloc 438, said to combine physical and handling characteristics of epoxies with high-temperature performance of phenolics. Dow Chemical Co, Midland, Mich.

Circle 355 on Reader Service Card

WIRE-MESH HEATING ELEMENT—Catalog WMB-2-459, 16 pp. Covers features, physical properties, thermal characteristics and applications of wire-mesh heating element. Electrofilm Inc, 7116 Laurel Canyon Blvd, N Hollywood, Calif.

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BEARING UNITS—Catalog BU-103-A, 20 pp. Contains load rating and comparison charts and specifications on pil-

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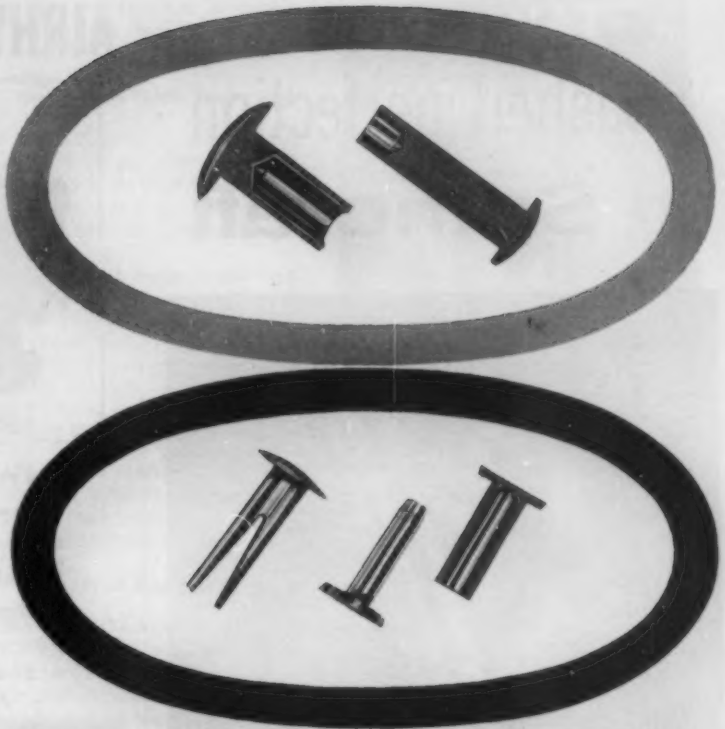

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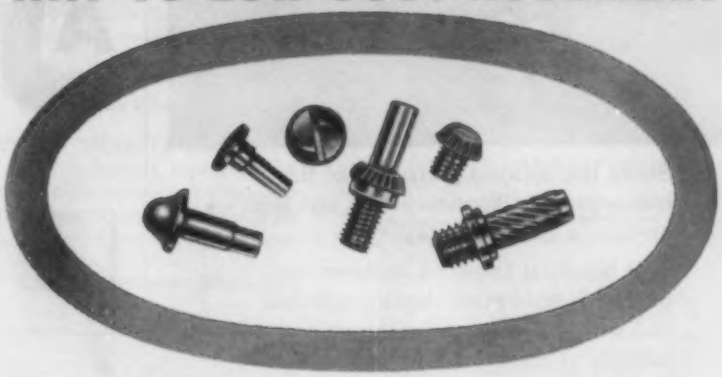

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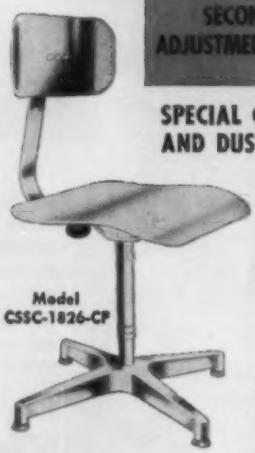

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FASTENERS FOR HONEYCOMB—Booklet, 10 pp. Gives sizes, specifications, and installation information on floating and rigid barrel nuts, SL-60 bearing nut and lockwasher assembly, clip nut for sheetmetal fastening. Shur-lok Corp, 879 S East St, Anaheim, Calif.
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ELECTRIC CONTROLS—Brochure P-75, 8 pp. Describes standard, special and custom controls used to actuate electric brakes and clutches. Covers operation, dimentions and selection. Warner Electric Brake & Clutch Co, Beloit, Wis.
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PERMANENT-MAGNET PULLEYS—Bulletin 1022, 6 pp. Dimensions, specifications and characteristics of 12- to 48-in.-dia pulleys. Includes selection chart. Stearns Magnetic Products, 635 S 28th St, Milwaukee 46.
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POLYCARBONATE RESIN—Bulletin TIB 41-Mi, 6 pp. Describes physical and electrical properties of thermoplastic resin. Compares it with seven other plastics to show characteristics. Mobay Products Co, 1815 Washington Rd, Pittsburgh 34.
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RUBBER-ENCASED PENDENT SWITCHES—Bulletin 79, 8 pp. Describes nine pendent switches for electric hoist control. Fold-back page in bulletin presents front, back and interior views of station. Joy Mfg Co, Electrical Products Div, 1201 Macklind Ave, St Louis 10.
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GEARMOTORS AND MOTOR REDUCERS—Bulletin 198, 8 pp. Describes and illustrates features of design, basic types and modifications, as well as universal mounting positions in which units may be used. Sterling Electric Motors, Inc, 5401 Telegraph Rd, Los Angeles 22.
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NEMA C-FACE SPEED REDUCER—Brochure 5-250, 6 pp. Describes speed reducer designed to accept NEMA C face-mounted motors, ½ to 5 hp. Janette Electric Mfg Co, 8350 N Lehigh, Morton Grove, Ill.
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MOTORS AND RELAYS—Reference file folder F-9765, 4 pp. Typical specification on line of ac and dc fhp motors, tachometer generators and ultrasensitive relays. Lists rated hp, dimensions, special features and typical applications. Barber-Colman Co, Rockford, Ill.
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STOCK ROTARY SWITCHES—Stock catalog 399, 4 pp. Lists 124 types and sizes of rotary switches available from stock. Includes specifications and prices. Oak Mfg Co, 1260 Clybourn Ave, Chicago 10.
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VIBRATION MOUNTS—Bulletin 59-04.6, 2 pp. Specifications, application and performance information, and dimensions of vibration- and noise-isolation mounts for light loads. Barry Controls Inc, 700 Pleasant St, Watertown 72, Mass.
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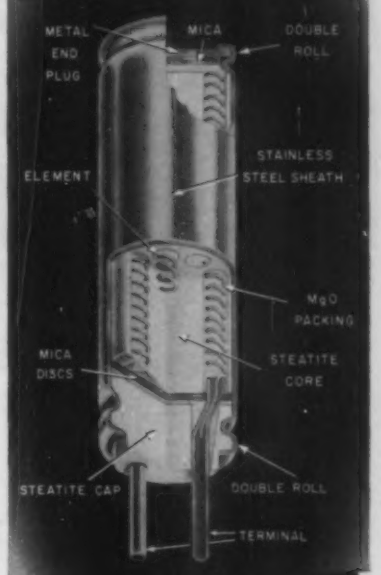

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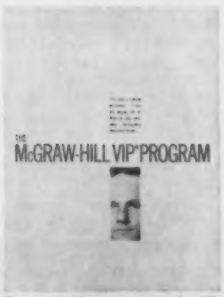

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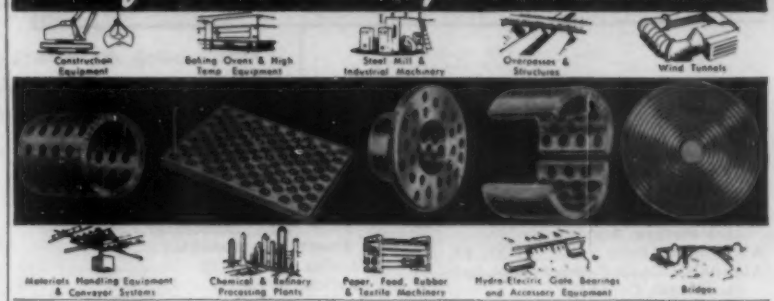
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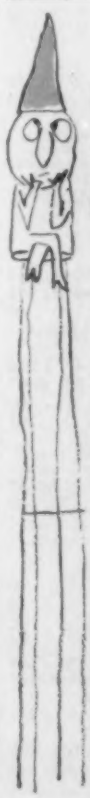

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Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

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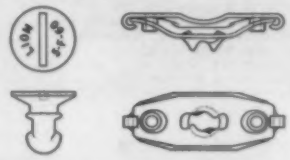
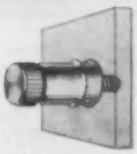
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.





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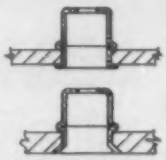
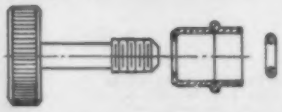
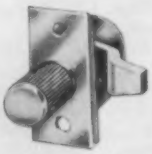
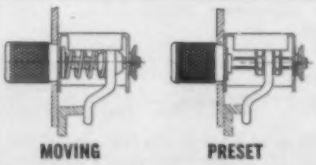






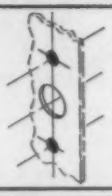
ADJUSTABLE PAWL FASTENERS

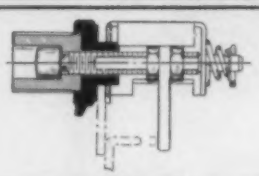
Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.



ADJUSTABLE PAWL FASTENER

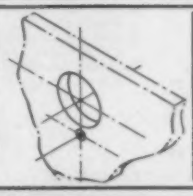
Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.

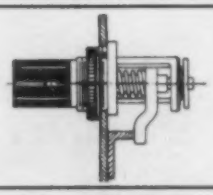




ADJUSTABLE PAWL FASTENER

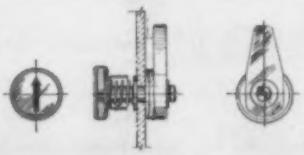
Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.





ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



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5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
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15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

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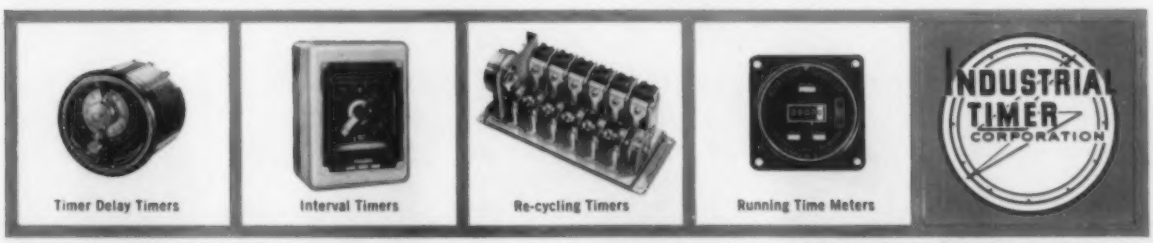

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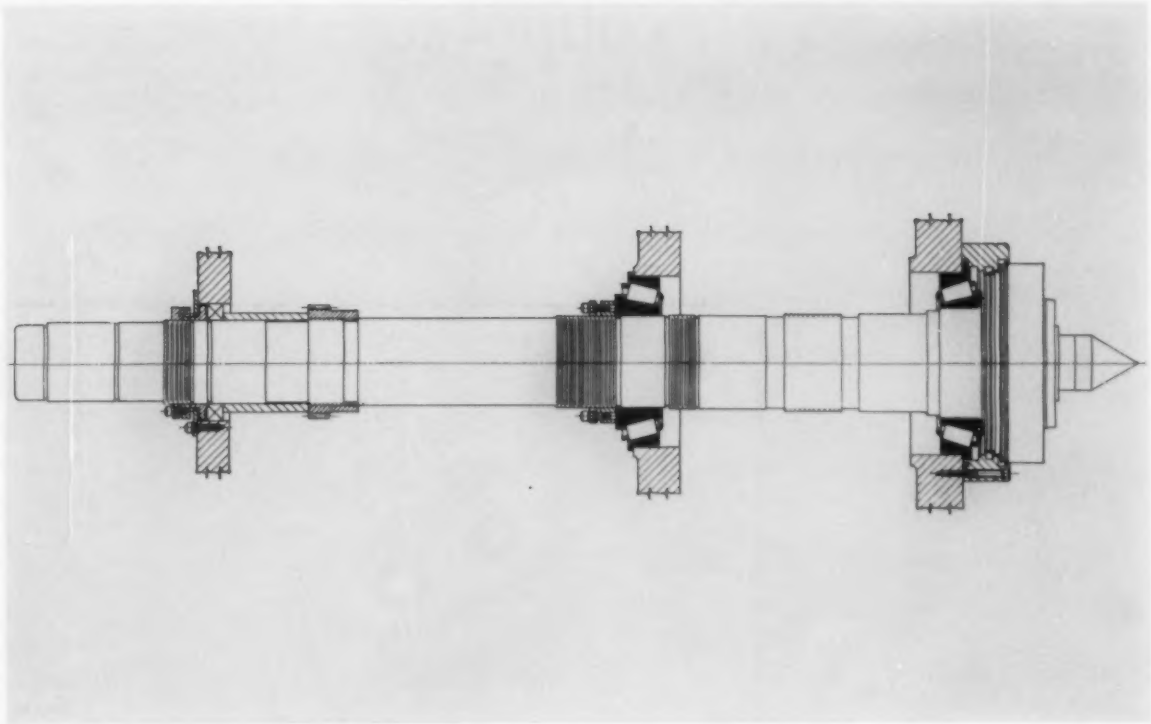
How Monarch assures rigidity, accuracy, with Timken® bearings in "Dyna-Shift" lathe



IN designing their Series 90 Dyna-Shift lathe that can be kept under full load at any speed, Monarch engineers wanted to be sure of rigidity, accuracy and economy. By using 30 Timken® tapered roller bearings at vital points—spindle (shown above), gear box, apron and tailstock—the engineers achieved their objectives. Results from the "90", reports Monarch, show up to 25% more output and 50% greater tool life than with other equipment.

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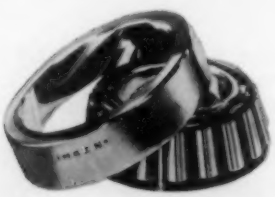

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